APPENDIX H

HYDROLOGY AND SURFACE WATER STUDY

DISCLAIMER

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Subject to that declaration:

(a) in writing this document, Iron Road Limited has relied on information provided by specialist consultants, government agencies, and other third parties. Iron Road Limited has reviewed all information to the best of its ability but does not take responsibility for the accuracy or completeness; and

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REPORT

CEIP - HYDROLOGY AND SURFACE WATER MANAGEMENT STUDY

E-F-34-RPT-0026

Revision	Issue Date	Revision Description	Document Author	Checked By	Approved By
A	11/09/2013	Draft TOC for Client Review	Alfonso Perez	Dean Delahunty	
B	6/11/2013	Updated draft, addressing Client Review comments on Sections 1-5	Alfonso Perez, Hugh Middlemis	Dean Delahunty	
C	06/12/2013	Completed Draft Report	Alfonso Perez, Hugh Middlemis	Dean Delahunty	
D	20/12/2013	Final Report	Alfonso Perez, Hugh Middlemis	Dean Delahunty	
E	8/10/2015	Final Report including amendments to mine site layout	Rachel Meinig, Nathan Heinrich	Dean Delahunty	

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Executive Summary

RPS was engaged by Iron Road Limited (IRD) to undertake the hydrology study component of a Definitive Feasibility Study (DFS) associated with its Central Eyre Iron Project (CEIP) near Warramboo.

The Study covers the regional and local surface water and its interaction with the proposed mine, including:

- Accumulation of ponded volumes in the swales and low lying areas located within the Mine Lease boundary, and variations through pre-mining, during mining and post-mining conditions.
- In-pit surface water volume estimation, for average monthly and for major rainfall events.
- Protection of identified mining infrastructure that may be affected by surface water.

As part of the study a field visit was conducted in May 2013 which included interviews with local residents and stakeholders, as well as completion of an infiltration test.

The CEIP project area is characterised by low relief sandy dunes, with swales and associated low lying areas that form localised depressions with no surface outlets, and some intervening plateau areas. Discussions with Wudinna Council staff confirmed that the low lying areas and swales are not interconnected (i.e. there is no network of creeks or other surface drainage channels). The main hydrological process on the natural land surface at the CEIP is not one of rainfall-runoff, but more one of rainfall-infiltration (except in impervious areas, which are commonly engineered surfaces such as roads). The area is subject to relatively low rainfall intensities, relatively high evaporation and the surface materials are generally permeable (apart from low lying areas), favoring water infiltration. The water pondages observed at swales within low-lying areas arise due to sub-surface drainage of infiltrated rainfall. The rainfall infiltration eventually causes a rise in the water table, and this combines with the saturation of near-surface materials in the low lying areas and swales due to continued rainfall and lower evaporation during winter to result in water ponding. There is no evidence of surface runoff processes (i.e. no creek or drainage network and no surface connection of ponding in low lying areas and swales). This study has found that summer rainfall is a low risk for significant ponding, consistent with the anecdotal views of local landholders.

This study developed a methodology to calculate the ponded volumes in swales and low lying areas, based on a monthly balance of rainfall, evaporation, infiltration and percolation to deeper aquifers. The Central Eyre Water Balance (CEWB) model has been benchmarked against the surveyed extent of the ponded areas in July 2013.

The CEWB model has been run for a number of scenarios for pre-mining, during mining and post-mining conditions (Table 1), and results have been compared for:

- An average hydrological year (i.e. average monthly rainfall).
- An exceptional dry year (1957).
- Exceptionally wet years (1968 and 1992).
- High summer or winter rainfall years (2011 and 1979).
- Current year (2013) for the model calibration.

The mine lease area has three key surface water areas / catchments which are treated separately in the analysis of surface water processes and characteristics.

Mine processing area surface water

The volumes of water potentially ponding in swales (sub-catchment CH2) will change during mining due mainly to the excavation of the pits within the low lying areas, which intercepts a percentage of sub-surface drainage, but also due to the loss of contributing draining areas. After mining the calculated ponded volumes change again due mainly to the recovery of certain contributing catchments due to the rehabilitation of the installation and process facilities area.

For exceptionally wet years (like 1968), the prediction is that ponded water volumes may fill or exceed the available storage volumes at the swales. These ponded areas are known to arise mainly during winter periods, and usually dissipate (via infiltration and evaporation) naturally during the spring period, and this process would not be significantly affected by the mining operation (except for certain swales discussed below).

Table 1: Summary of Ponded volumes (ML) at swales and low lying areas within the mine Lease (ex-pit)

Scenario	Pre-Mining	During Mining (Y1 to Y21)	Post-Mining
Average (generated)	55	40 to 32	33
Lowest annual rainfall total (1957)	12	8 to 6	6
Highest annual rainfall total (1968)	1,522	1,000 to 796	821
2^{nd} highest annual rainfall total; wet spring & summer (1992)	333	216 to 172	178
High winter rainfall (1979)	749	491 to 391	403
High summer rainfall (2011)	55	35 to 28	29
Calibration data to July (2013)	288	186 to 149	153

Five swales have been identified in the proximity of the open pits and processing facilities, namely swales S9, S10, S16, S19 and S20 (see Figure 7). Construction of drains to prevent ponding, subsequent increasing infiltration to the open pits, nuisance effects on surface infrastructure and geotechnical instability of the pit walls will be necessary to manage risks.

Drainage of these swales could be achieved by installing trench drains reporting to a collection sump, where a pump would direct flows to the Mine Process Pond for its use in the Process Plant (see section 6.2). The design for the swales drainage system is described in section 6 and the predicted surface water volumes to be drained from swales indicated in Table 23 are designed for input to the site water balance assessment (SysCAD).

In-pit surface water

In-pit surface water volumes have been calculated using Volumetric Runoff Coefficients (VRC) developed by RPS for a range of mines in South Australia and Western Australia. To calculate the monthly surface water volumes reporting to the pit floor, the VRC value for the 2 year ARI and less is applied to the monthly rainfall for a range of scenarios and specified periods of pit development. The results are presented in Table 16 and again these are designed for input to the site water balance assessment (SysCAD).

The maximum surface water volumes reporting to the floor of the pit for major rainfall events have been calculated for a 72 hr duration storm with return periods ranging from 2 year ARI to 100 year ARI. While the design of the in-pit drainage and pumping infrastructure is being undertaken by others, we suggest consideration of a 50 year ARI event as a suitable design basis, as it has a probability of occurrence of 33% over the 20 years of mine life.

Surface water for other site drainage issues

Finally the study considered other sub-catchments within the Mine Lease Boundary where drainage could be affected by the proposed mine infrastructure. In particular, the Integrated Waste Landform (IWL) and the mine pits themselves could potentially modify small to medium sized drainage catchments.

The IWL will be constructed progressively and will cover five sub-catchments that naturally drain to swales along the southern mine lease boundary and one that partially drains internally. Completion of minor earthwork to create bunds along low points in swales in this area will be sufficient to mitigate any risks of water moving beyond the mine lease boundary prior to IWL construction.

Construction of a broad collection drain along the perimeter of the IWL will ensure that any runoff from the revegetated batter on the first lift of the IWL will be contained on site and dissipated at natural low points in a similar process to what happens with other swales in pre-mining condition (i.e. infiltration and evaporation). The storage volume available within low points along this drain will also be complemented by the bunds that are proposed for containing swale storage prior to construction of the waste landform. The actual storage volume available will need to be determined on a rolling basis as the IWL is constructed. This is because the volume of runoff and the storage location will change regularly during mine operation. Guidance on this should be based on the calculated maximum runoff rate being in the order of 17ML/km.

The hydrological assessment generally concludes that surface runoff is highly unlikely where the catchments are elevated more than 20m above the low lying areas, other than temporarily and localised flows that may occur prior to infiltration in major events. The general locations where rainfall may report to the surface are where the saturation of the soil profile in lower lying areas occurs during wetter (winter) periods which results in water collecting in swales as well as at the base of the IWL. The volumes of water expected under a range of scenarios have been calculated and are manageable.

It is recommended as good practice that a minimum degree of erosion protection be provided in any IWL drains and service roads. Similar protection is recommended for the bund around the open pit excavation, in particular the 325 m section of the southern side of Murphys Pit in contact with swales S19 and S20.

The typical protection works should consist of a layer of rock (75 to 150mm equivalent diameter) with separating geotextile underlying it. The design requirements for the drainage protection are described in Section 6.

1 Introduction

RPS was engaged by Iron Road Limited (IRD) to undertake the hydrology study component of a Definitive Feasibility Study (DFS) associated with its Central Eyre Iron Project (CEIP) near Warramboo (see Figure 1 and Figure 2).

The DFS requirement for the assessment of surface water is for sufficiently detailed investigations and conceptual hydraulic designs to allow a +/- 15% cost estimate for the works required to manage surface water for the site, at least for the start-up and commissioning phase of the project.

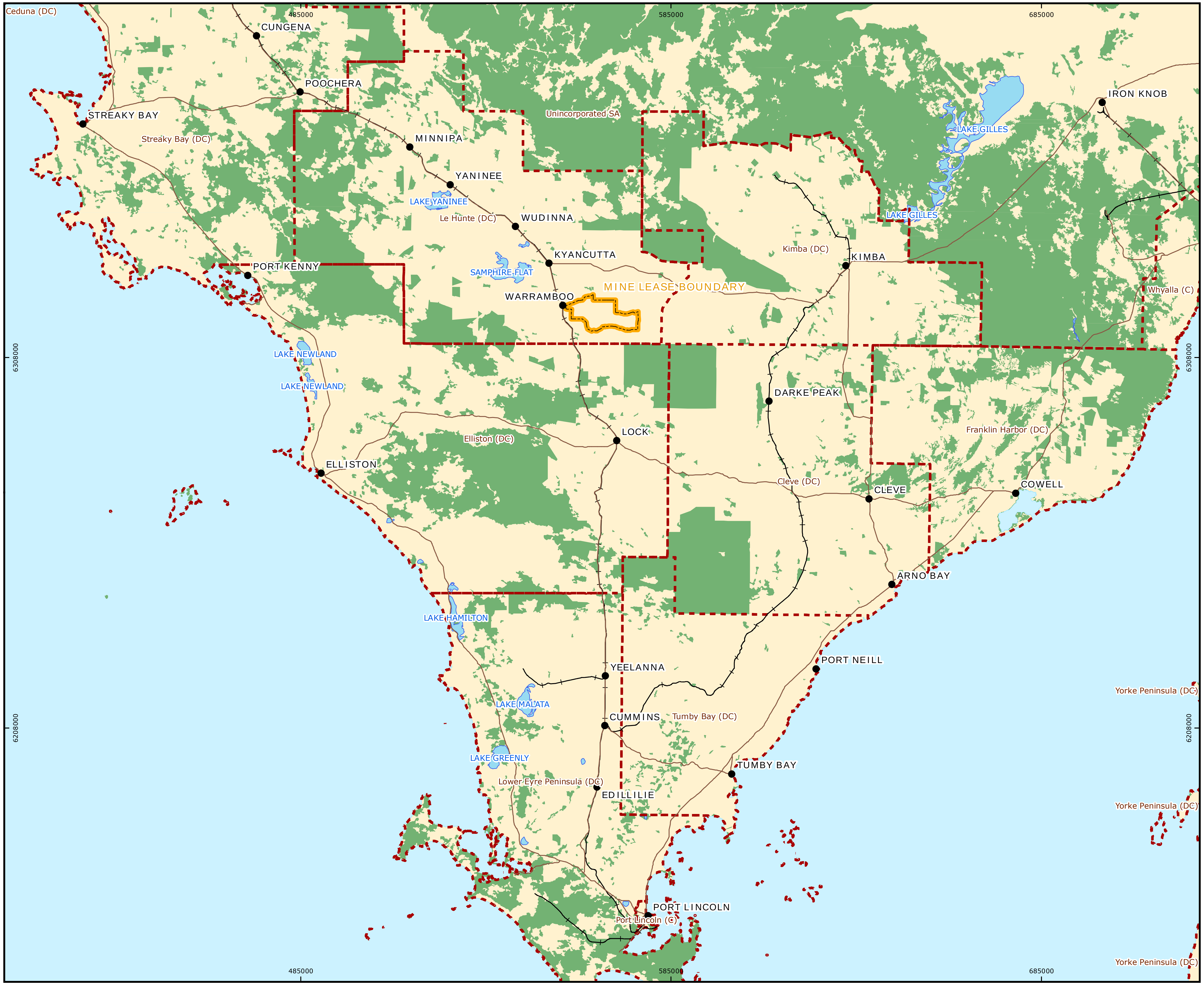
The extent of this hydrology study is limited to the management of surface water in and around the CEIP mine site including assessment of catchment areas capable of contributing surface water flows to the mine site. The exclusion from the analysis is management of processing plant and equipment.

Key investigative sub-tasks for this study included:

- Collation of data.
- Field visit and dual-ring infiltration test.
- Hydrological census (questionnaire survey of landholders and Wudinna Council staff).
- Survey of the catchments draining to low lying areas and swales during winter 2013 (to benchmark hydrological analysis).
- Hydrological analysis.
- Engineering concept design and cost estimate preparation for input to DFS.

The purpose of the study is to identify and characterise the surface water components that may affect or be affected by the future mine operations. The study quantifies to DFS level the storage volumes and flows for surface water management around infrastructure. DFS cost estimates have been reported separately.

The water volumes calculated are also designed for input to the mine site water balance (SysCad) being developed by others.



LEGEND

- Locality
- Road
- Railway
- Local Government Area
- Lakes
- Native Vegetation Area
- Mine Lease Boundary

N

10 0 10 20

Kilometers

APPROX SCALE 1:1,000,000 @ A3

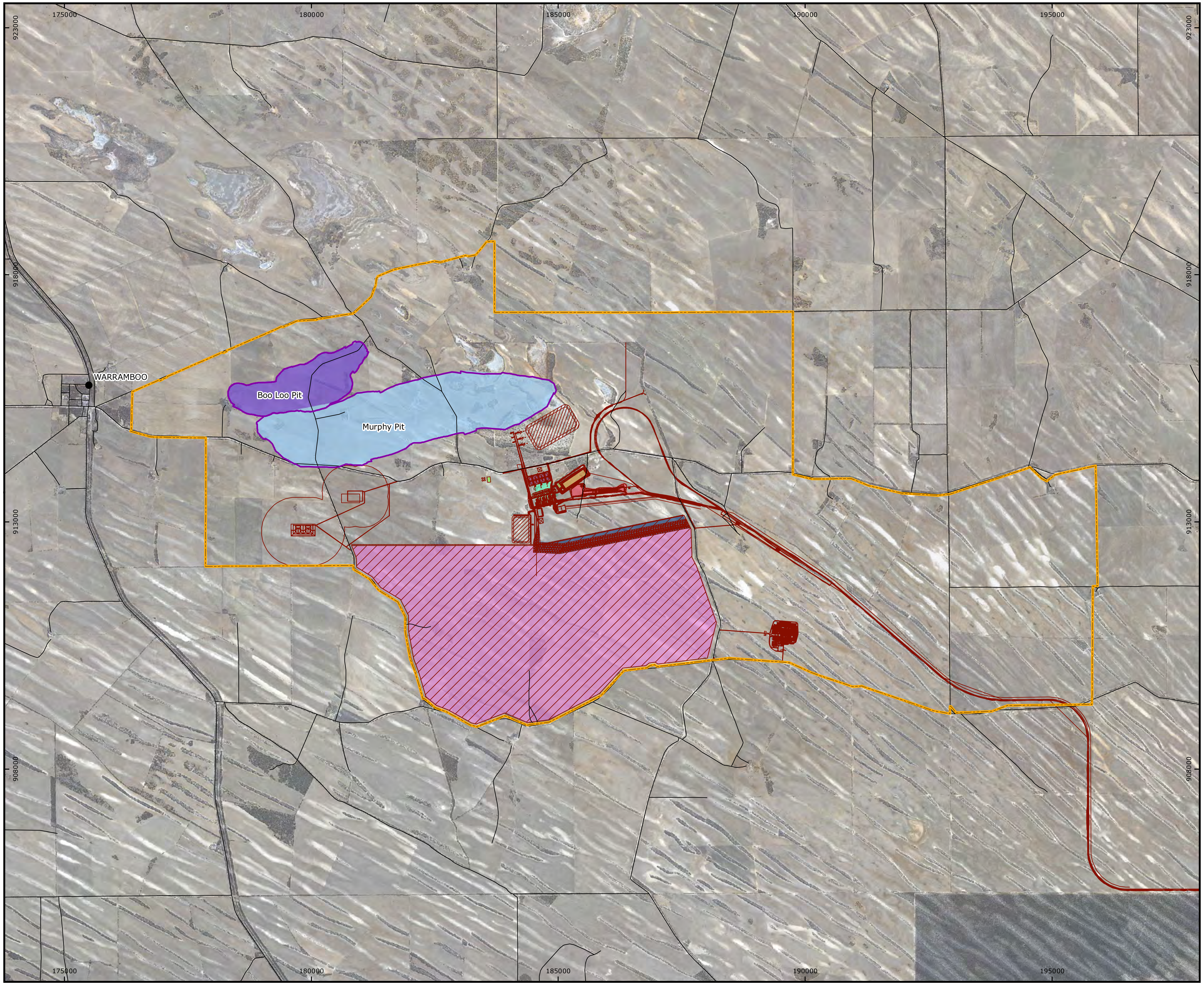
DATA SOURCES

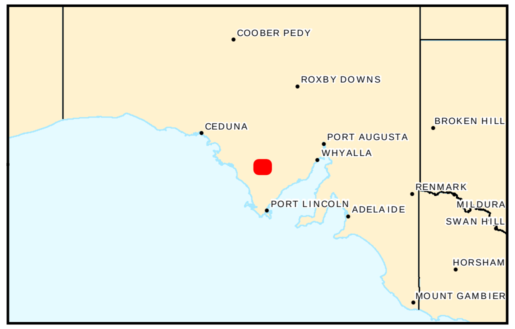
RPS

RPS Aquaterra

FIGURE 1

CEIP Locality Map





LEGEND

- Locality
- Road
- Pit Limits
- October Updated Mine 2014108
- Proposed Mine Lease Boundary

Infrastructure

- Administration
- Boo Loo Pit
- Concentrate handling facilities
- Engineering shop inset
- Groundwater storage dam
- Integrated landform spreaders
- Integrated waste landform
- Maintenance facility
- Mine heavy vehicle workshop inset
- Murphy South Pit
- Ore processing facility
- Ore stockpile area
- RO Plant

N

1,000 0 1,000 2,000

Metres

APPROX SCALE 1:75,000 @ A3

GDA 1994 MGA Zone 54

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Please verify the accuracy of all information prior to use.

RPS

FIGURE 2

CEIP Mine Site

2 Site Visit and Hydrological Characterisation

This section summarises the findings and conclusions of the site visit conducted on 3rd of May 2013. The attendees to the site visit were Ben Jeuken (IRD), Tim Scholz (IRD), Richard Clark (independent consultant), Hugh Middlemis (RPS) and Alfonso Perez (RPS).

Prior to the visit a hydrologic census (questionnaire) was distributed amongst landholders in an effort to capture as much local knowledge as possible. Two questionnaires have been returned with useful information for the understanding of the local hydrology. A simple dual-ring infiltration test was also performed during the site visit. Interviews were held with the Wudinna Council staff, as well as with a number of local landholders.

The following points on the local hydrological characteristics summarise the conclusions drawn from the site inspection, interviews and infiltration test:

- The CEIP project area is characterised by low relief sandy dunes, with swales and associated low lying areas, and some intervening plateau areas. The dune and swale systems trend to the North West and the low lying areas form localised depressions with no surface outlets.
- Local catchments drain to the low lying areas forming swale pondages to shallow depths for several weeks during winter. The water depth is typically less than 0.5m, depending on the swale topology. The ponding was described (by hydrological census interviewees) to be due to high infiltration of rainfall through the sandy soils in dune areas and accumulation of water in low lying areas that have no surface drainage outlet, augmented by raised water table levels during winter. Analysis of data by RPS indicates that the low evaporation and more regular rainfall during winter would sustain this process. Measurements of ponded areas were subsequently taken during winter 2013 to provide data for benchmarking the hydrological analysis (see section 4.3).
- There is no evidence of surface runoff processes (i.e. no creeks or drainage network) and no surface connection of ponding in low lying areas and swales.
- Major rainfall events are typically recorded during the summer months, (as noted by locals and shown in Figure 11) and could cause localised temporary runoff but, as observed, not to the extent that it has resulted in established or defined water courses. During these events, high rainfall intensities may saturate the soil in a short period of time and could result in temporary runoff, which typically would dissipate and drain away within a few hours without causing major disruption.
- Discussions with Wudinna Council staff confirmed that the low lying areas and swales are not interconnected (i.e. there is no network of creeks or other surface drainage channels), and that stormwater management (e.g. for roads and impervious areas) is implemented by excavating shallow drainage channels towards low lying areas within road reserves to form effective infiltration ponds.
- The infiltration test completed during the site visit was used to estimate the saturated hydraulic conductivity (K) of the sandy soils found at the project site, for use in the subsequent hydrological analysis. This K value was found to be 1.2×10^{-4} m/s, which is classified as medium permeability with good drainage conditions, typical of clean sands with low fines content (Terzhagi, Peck and Mesri, 1996), and consistent with field observation of the character of the surface soils.

Further details of the site visit, including photography coverage and details of the infiltration test can be found in Appendices A to C.

3 Existing Surface Water Environment

3.1 Data

The hydrological data sets collated and analysed include:

- Hydrologic background information for the Eyre Peninsula (EP),
- Bureau of Meteorology (BoM) climate data,
- Land form (contours and digital elevation model or DEM) for most of the proposed mine lease,
- Soils maps and relevant references describing soil properties / characteristics,
- Existing site geotechnical drilling / sampling data, and
- Other reports relevant to the local area, notably from government agencies. (see section 9 for details).

3.2 Regional Setting, Topography and Land use

The CEIP is located within the Eyre Peninsula Natural Resource Management (EPNRM) region, which covers 80,000km^2, stretching from above Whyalla in the Upper Spencer Gulf, across the area south of the Gawler Ranges, west to Ceduna and south to Port Lincoln at the tip of the peninsula (EPNRM 2009). Eyre Peninsula has a characteristic Mediterranean climate, with warm to dry summers and cool, wet winters (EPNRM 2009). It enjoys a mild, moist, coastal climate in the south and southwest, with a warmer, drier climate inland to the north, where the CEIP project area sits.

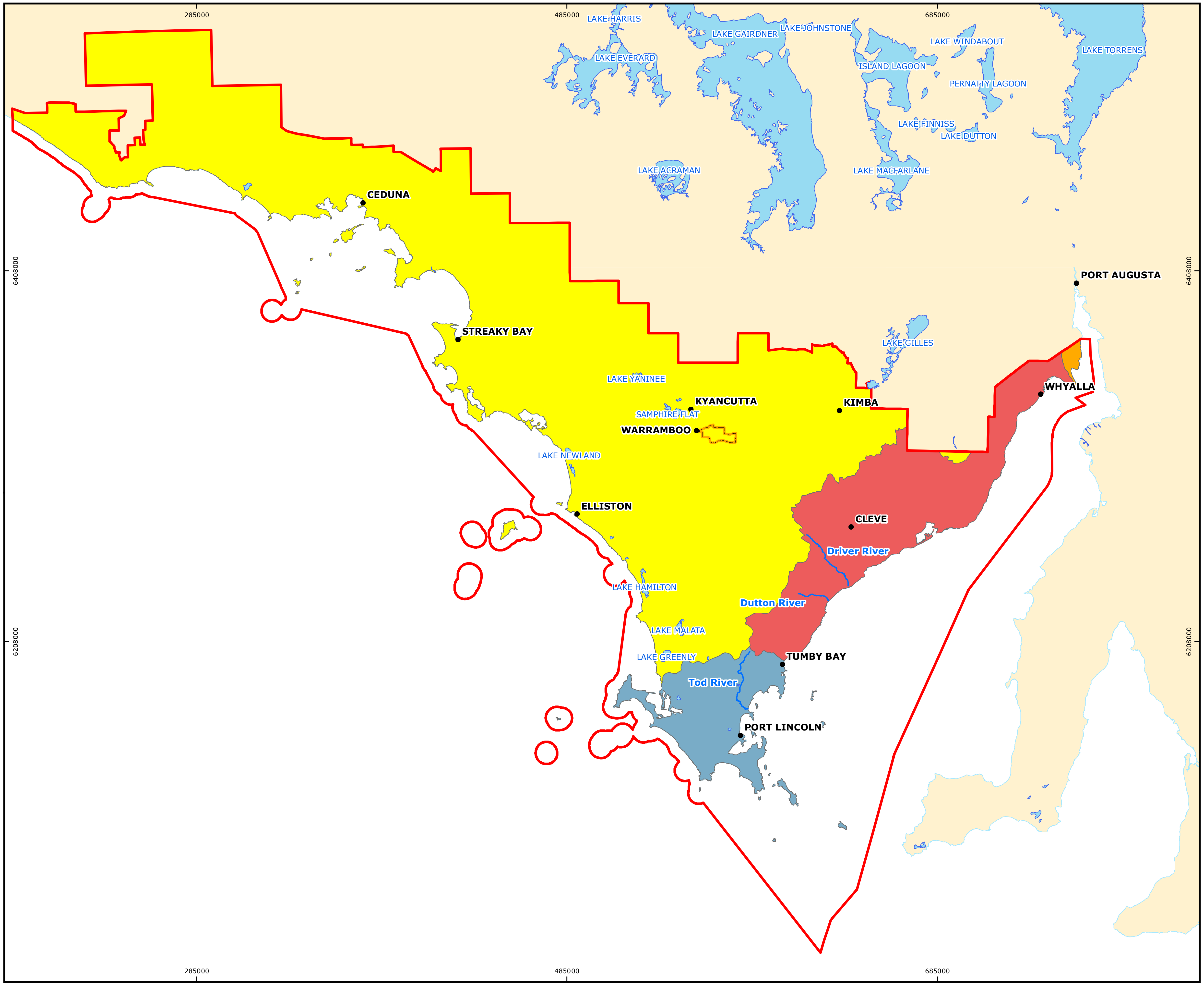
The Eyre Peninsula is a large relatively flat landscape, consisting mainly of plains with isolated and low peaks and discontinuous ranges, with an extensive cover of old dune systems and sand sheets (Eyre Peninsula Catchment Water Management Board, 2005). The hydrology of the Eyre Peninsula is defined by three surface drainage basins: the Eyre Peninsula Basin, Spencer Gulf Basin, and the Gairdner Basin (see Figure 3). The Gairdner Basin covers the majority of the EPNRM area, including the CEIP project area. It has no major surface water drainage system, mainly due to surface water flow on the EP being limited to the eastern and southern ranges, outside the Gairdner Basin (Li Wen, 2005).

The CEIP project area has no creeks or rivers and has no identified wetlands of national or international importance. There are occurrences of episodic ponding (type B8, or seasonal intermittent saline lakes) that are associated with low-lying areas and swales (Seaman, 2002).

In the central and western regions of the EP, as well as the coastal plain southwest of Whyalla, the flat terrain does not exhibit an identifiable surface drainage network. In these areas, rainfall typically either evaporates or infiltrates rather than generates runoff, but generates low rates of subsequent recharge to the groundwater system (Li Wen, 2005).

In the northern EP, there are minor surface drainage features from the Cleve Hills towards the north and the south. Elsewhere in the northern-central EP, the relatively flat topography combined with low rainfall and high evaporation results in limited surface water resources (DFW, 2011). Due to generally highly permeable surface geology, most of the rainfall infiltrates the soil without producing runoff, except when rainfall intensity is elevated.

The CEIP area lies in the central-northern part of the EP, and local conditions comprise a dune and swale system with no surface drainage outlets, where most rainfall infiltrates or evaporates without producing runoff.



APPROX SCALE 1:2,000,000 @ A3

DATA SOURCES

RPS
GA

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Please verify the accuracy of all information prior to use.

FIGURE 3

Eyre Penisula Hydrololgy

Within the project area, the land surface is characterised by lines of sand dune systems with a north-west trend. Surface elevations within the area of study range from up to approximately 145mAHD in the northeast, down to 60mAHD at ephemeral swale pondages, which have no surface drainage outlets.

The land surface within the CEIP Mine Lease has elevations ranging from 110 m AHD to 60 m AHD (Figure 4).

Since European settlement, significant clearing of native vegetation was undertaken to develop primary agricultural production (Eyre Peninsula Catchment Water Management Board 2005). Areas of conservation are present as well as remnant patches of native vegetation (EPNRM 2009) which are typically found as small, distinct scrub areas on farmland, where land and soils are less suited to agriculture, such as deep sands or sheet limestone. The project area is surrounded largely by land used for dryland agriculture production, with scattered patches of uncleared native vegetation (typically scrub). Several conservation areas are well outside the mining lease area, including Hambridge Conservation Park to the southeast, Cocata to the west, Pinkawillinie to the north and Barwell to the south (see Figure 1). The Musgrave Prescribed Wells Area (PWA), also known as the Polda Basin, is located about 40 km to the southwest, but there is no direct geological or hydrogeological connection between the CEIP and the Polda Basin.

3.3 Geology and Soil Permeability

The CEIP is located in the Sleaford Complex of the Coulta sub-domain, which forms part of the Gawler Craton, a major crustal province in southern Australia. The Sleaford Complex is an Archaean granitic gneiss, which outcrops to the north of the CEIP as basement (Coffey, 2013 and Iron Road, 2011). It is very poorly exposed across the mining lease and almost entirely covered by younger sediments, deposited during the Cainozoic era when a veneer of fairly thin, largely alluvial sediments blanketed the Eyre Peninsula. Extensive aeolian dune sands, alluvial sands, silts and conglomerates, and thin but often very tough calcareous layers form a thin veneer rarely more than a few metres thick covering almost the entire peninsula (EPNRM 2009).

The ore body overburden includes Quaternary and Tertiary sediments (Figure 5). The Quaternary unit consists of aeolian sands, clayey sand, calcarenite and calcrete, primarily from the Moornaba Sand and Bridgewater Formation. Tertiary sediments comprise unnamed silts, clays and minor sand with some limestone, calcrete and carbonaceous material (Coffey, 2013). The Tertiary Yaninee Palaeochannel is delineated on maps as a broad shallow depression in the area mainly west of Wudinna and north up to Lake Yaninee. These palaeochannel sediments comprise sands and muds laid down in environments ranging from alluvial, through lacustrine to marine. The geological and hydrogeological mapping demonstrates that the surficial dune and swale system in the CEIP area itself is not connected with the deeper palaeochannel deposits, unlike in the area of Lake Yaninee, 30km north-west of the CEIP, where the Yaninee palaeochannel sediments do underlie the surficial dune and swale sediments.

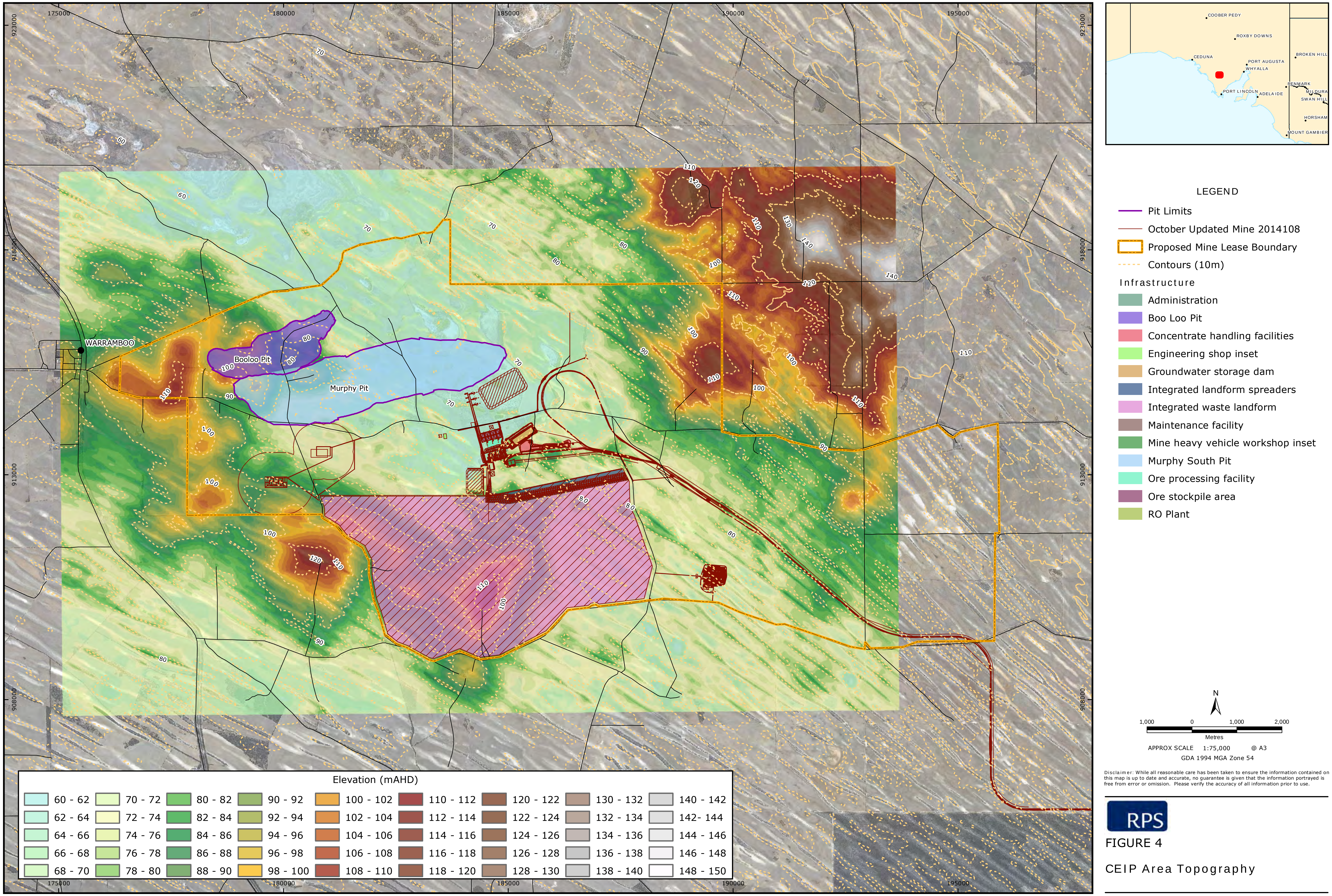
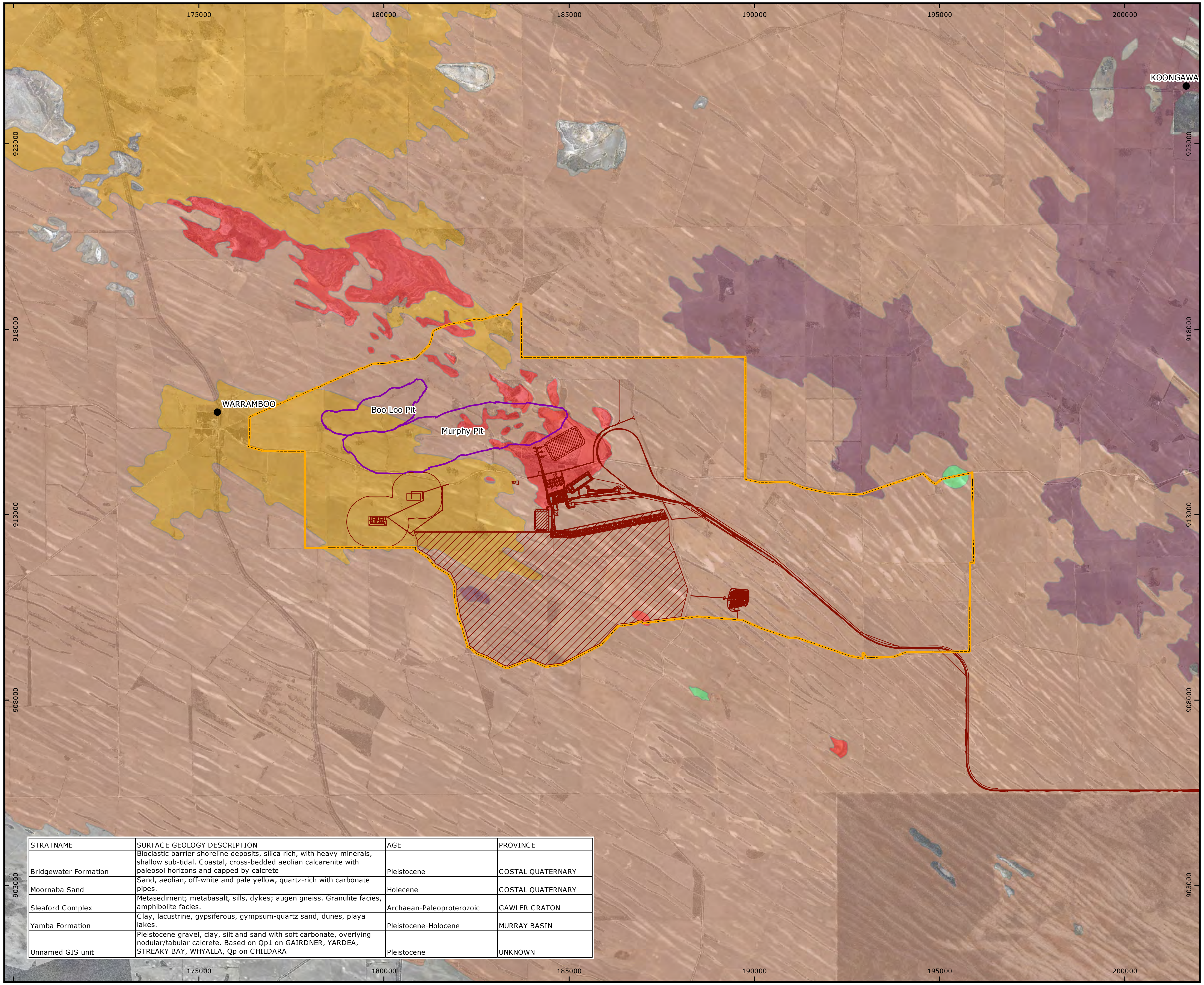
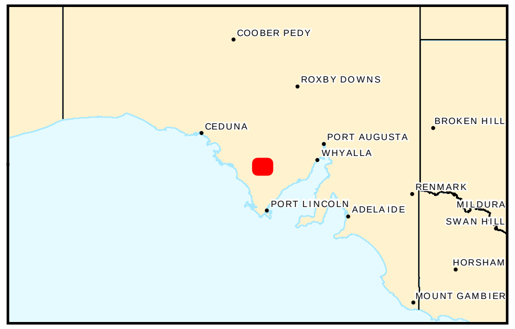


FIGURE 4

CEIP Area Topography



STRATNAME	SURFACE GEOLOGY DESCRIPTION	AGE	PROVINCE
Bridgewater Formation	Bioclastic barrier shoreline deposits, silica rich, with heavy minerals, shallow sub-tidal. Coastal, cross-bedded aeolian calcarenite with paleosol horizons and capped by calcrete	Pleistocene	COSTAL QUATERNARY
Moornaba Sand	Sand, aeolian, off-white and pale yellow, quartz-rich with carbonate pipes.	Holecene	COSTAL QUATERNARY
Sleaford Complex	Metasediment; metabasalt, sills, dykes; augen gneiss. Granulite facies, amphibolite facies.	Archaean-Paleoproterozoic	GAWLER CRATON
Yamba Formation	Clay, lacustrine, gypsiferous, gympsum-quartz sand, dunes, playa lakes.	Pleistocene-Holocene	MURRAY BASIN
Unnamed GIS unit	Pleistocene gravel, clay, silt and sand with soft carbonate, overlying nodular/tabular calcrete. Based on Qp1 on GAIRDNER, YARDEA, STREAKY BAY, WHYALLA, Qp on CHILDARA	Pleistocene	UNKNOWN



LEGEND

- Pit Limits
- October Updated Mine 2014108
- Proposed Mine Lease Boundary

Surface Geology

- Bridgewater Formation
- Moornaba Sand
- Sleaford Complex
- Yamba Formation
- Unnamed GIS Unit

N

1,000 0 1,000 2,000

Metres

APPROX SCALE 1:100,000 @ A3

GDA 1994 MGA Zone 54

RPS

FIGURE 5

Surface Geology

The soils have been classified into medium, low and very low permeability according to geology (Figure 6). The classification has been made using both the results of the infiltration test performed on site and following the typical permeability values for soils as described by Carter and Bentley (see Appendix C) and summarised in Table 2.

Table 2: Typical permeability vales for various types of soils

Permeability classification	Saturated Hydraulic Conductivity (m/s)	Soil description	Found on CEIP region?
High permeability soils	< 10^{-3} m/s	clean gravel, typically with more than 50% of coarse fraction larger than 5 mm	No
Medium permeability soils	10^{-4} m/s	clean sands, sand and gravel mixtures, typically with less than 12% of fine content	Yes, about 70% of the area of study
Low permeability soils	10^{-6} m/s	sand or clayey sand typically with more than 12% of fine content	Yes, about 25% of the area of study
Very low permeability soils	10^{-8} m/s	silts and clays, typically with more than 50% of fine content	Yes, about 5% of the area of study
Practically impermeable soils	> 10^{-9} m/s	very plastic clays, homogenous clays below the zone of weathering	No

The catchment surface is dominated by dune/swale systems. The dunal sandy material includes quartz-rich aeolian sand, siliceous sand and calcareous soil and subsoil resulting from the Moornaba Sand strata. It has a low water holding capacity and generates little runoff (EPNRM 2009). The saturated hydraulic conductivity of this soil was measured during the site visit using double ring infiltration test apparatus and found to be $1.2x10^{-4}$ m/s, medium permeability that corresponds to clean sands with little or no fines.

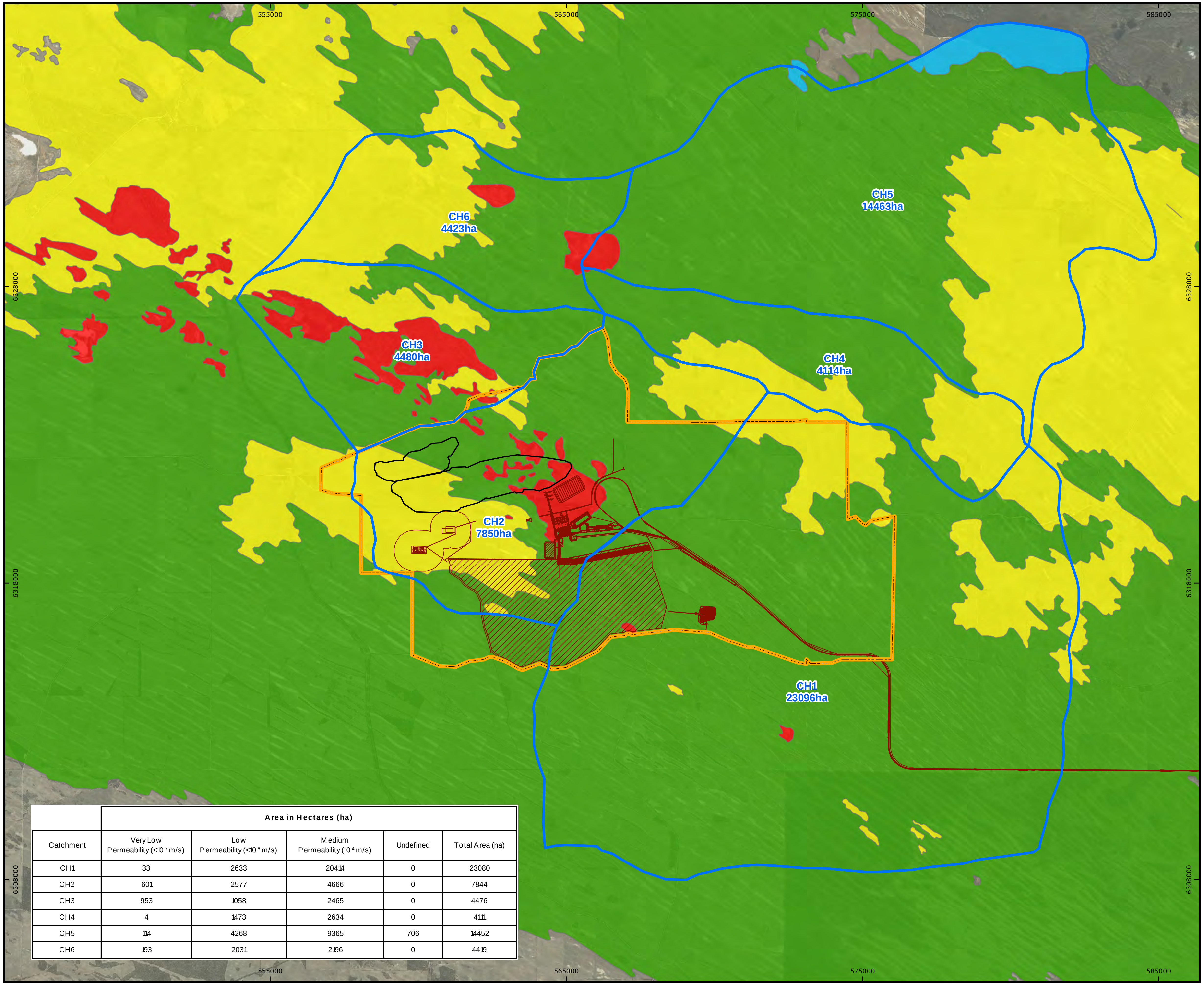
A portion of the area of study including the town of Warramboo and the highlands around the site is covered with a mixture of shelly sand to sandy loamy calcareous soil with some gravel, clay and silt, partially overlying calcrete. These materials originated from the Bridgewater Formation, Sleaford Complex and other unnamed units. Based on the material description these soils are expected to have low to medium permeability with a saturated hydraulic conductivity of about 10^{-6} m/s.

Low lying areas where typically fine deposits accumulates forming in some cases swales, the surface materials are generally clay, gypsum and gypsum-quartz sand associated with the Yamba Formation. These isolated areas are subject to winter ponding, and make up about 5% of the total area of study. Again based on the soil description, the saturated hydraulic conductivity of these materials is expected to be about 10^{-8} m/s, corresponding to text book values for soils with high content in fines and very low permeability.

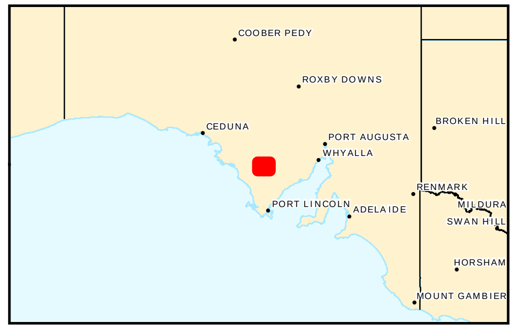
The saturated hydraulic conductivity values described above have been used in the hydrological model to calculate ponded volumes in the swales (see Section 4).

3.4 CEIP Project Area Hydrology

The CEIP site hydrology includes a number of low lying areas which are known to accumulate water during wet climatic sequences. During the winter months, rainfall is more consistent and evaporation is at its lowest, which generally results in soils in low-lying areas at or near full saturation. Under these conditions, winter rainfall infiltrates via the permeable and well-drained sandy soils on the dunes, causing higher groundwater levels and ponding in swales in the low lying areas. The swales are isolated by intervening dunes and the small areas of ponding are not connected at the surface. Temporary swale ponding can also occur following summer storm events, although the higher summer evaporation rates do not support long- term ponding.



	Area in Hectares (ha)				
Catchment	Very Low Permeability (<10^{-7} m/s)	Low Permeability (<10^{-6} m/s)	Medium Permeability (10^{-4} m/s)	Undefined	Total Area (ha)
CH1	33	2633	20414	0	23080
CH2	601	2577	4666	0	7844
CH3	953	1058	2465	0	4476
CH4	4	1473	2634	0	4111
CH5	114	4268	9365	706	14452
CH6	193	2031	2196	0	4419



LEGEND

Surfacewater Catchments

Pit Shells

Mine Lease Boundary

October Updated Mine 2014108

Expected Permeability (Derived From Geology)

Medium Permeability (≈10^{-4}m/s)

Low Permeability (≈10^{-6}m/s)

Very Low Permeability (<10^{-8}m/s)

Undefined

N

2.5 0 2.5 5

Kilometers

APPROX SCALE 1:125,000 @ A3

DATA SOURCES

RPS

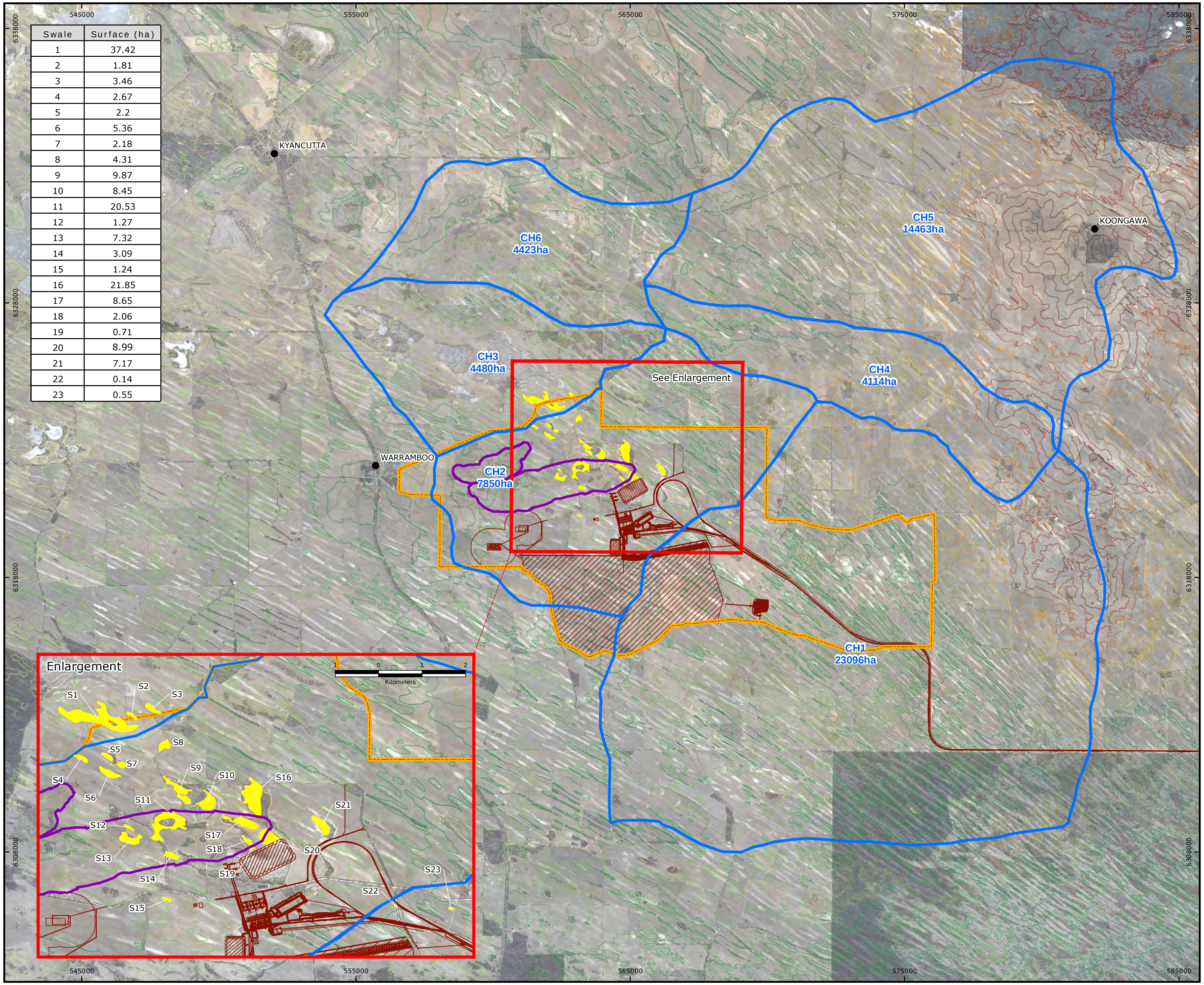
Geology Mapping Provided by I.R

RPS

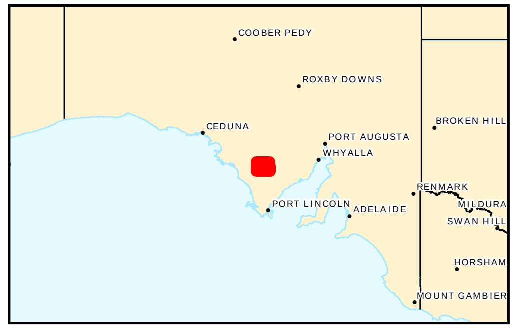
FIGURE 6

CEIP Area

Expected Soil Permeability



Swale	Surface (ha)
1	37.42
2	1.81
3	3.46
4	2.67
5	2.2
6	5.36
7	2.18
8	4.31
9	9.87
10	8.45
11	20.53
12	1.27
13	7.32
14	3.09
15	1.24
16	21.85
17	8.65
18	2.06
19	0.71
20	8.99
21	7.17
22	0.14
23	0.55



LEGEND

- Locality
- Pit Shells
- October Updated Mine 2014108
- Surfacewater Catchments
- Mine Lease Boundary
- Swale

Elevation

20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160, 170, 180, 190, 200, 210, 220, 230, 240, 250, 260

N

2.5 0 2.5 5
Kilometers

APPROX SCALE 1:135,000 @ A3

DATA SOURCES
RPS

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Please verify the accuracy of all information prior to use.

RPS

FIGURE 7

CEIP Surfacewater Catchment Area and Swales

There are six drainage catchments in the area of study (Figure 7):

- Catchment CH1 covers the southeast half of the proposed mine lease area, draining to the low lands in the south outside the project area.
- Catchment CH2 covers the northwest half of the proposed mine lease area, draining to the swales immediately adjacent to the TSF and the Murphys Pit (Swales S4 to S23 indicated on Figure 7).
- Catchment CH3 collects the drainage north of the proposed mine lease area draining to shallow swales to the northwest outside the project area (Swales S1 to S3 and other un-numbered swales on Figure 7).
- Catchments CH4, CH5 and CH6 collect the drainage from the highlands around Koongawa draining to the low lands further north-west and outside of the proposed mine lease area.

3.5 Climatology

The Eyre Peninsula has a characteristic semi-arid or Mediterranean climate, experiencing long hot and dry summers and cooler moist winters. The mean annual rainfall for the Eyre Peninsula ranges from 250mm in the Gawler Ranges in the north-northwest to more than 500mm towards the southern-most region, with approximately half of rainfall occurring between May and August on average.

The CEIP is located in the central north of the peninsula, 60 km south of the Gawler Ranges and approximately 80 km inland from the nearest coast in the west. The average annual rainfall for the project site is 325mm.

3.5.1 Temperature

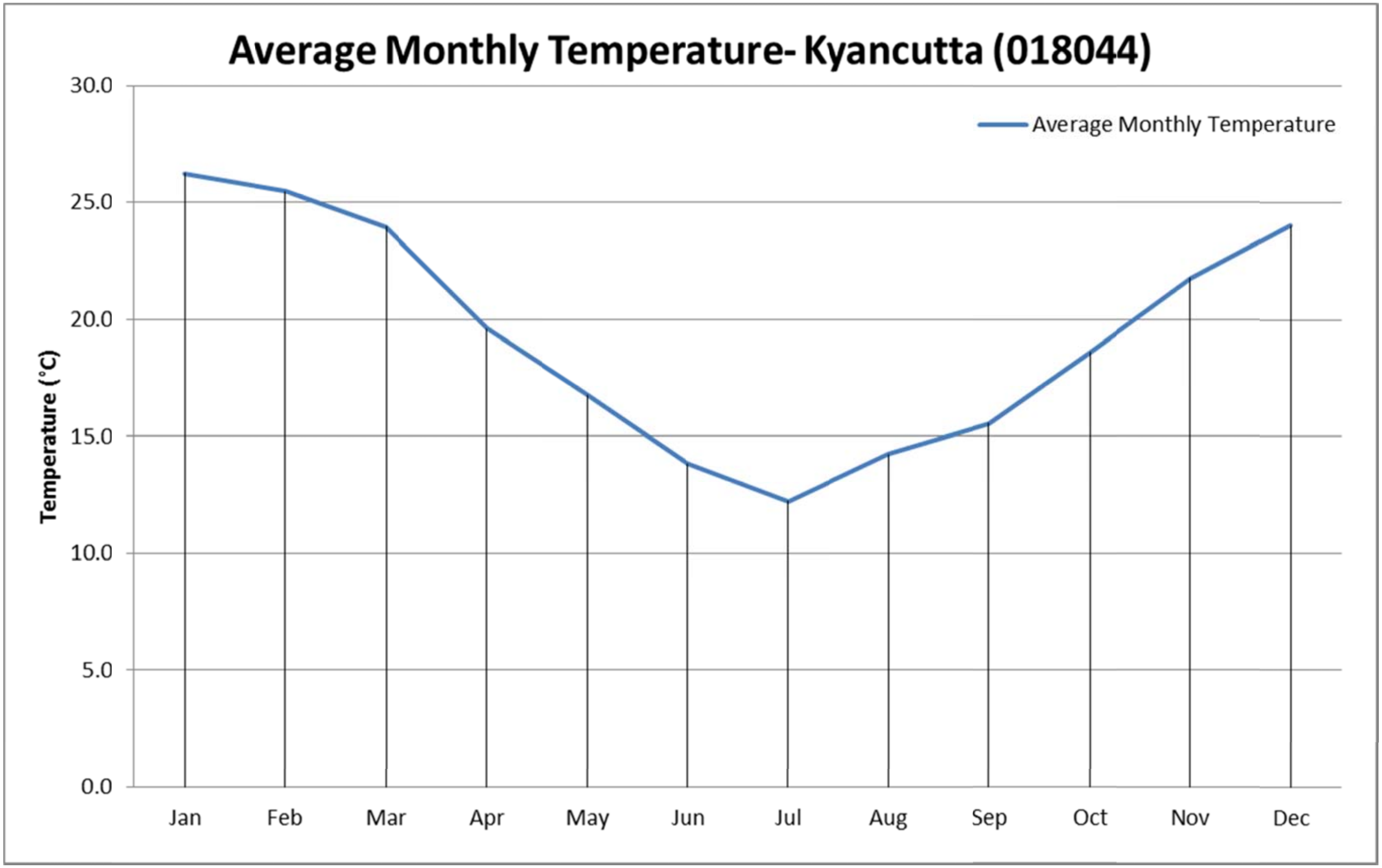
Temperature has been measured at the Kyancutta station (018044) since 1930. The mean maximum monthly temperature is highest in January, at 38.1°C and lowest in July, at 19.7°C (see Table 3 and Figure 8).

Table 3: Mean Monthly Temperature (°C) at Kyancutta Station 18044

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean Annual *
Mean Monthly Minimum	14.4	14.4	12.3	9.5	7.3	5.3	4.7	5.0	6.3	8.2	10.8	12.9	9.3
Mean Monthly Maximum	38.1	36.5	35.6	29.7	26.2	22.3	19.7	23.5	24.8	28.9	32.7	35.1	26.5
Average Monthly	26.2	25.5	24.0	19.6	16.8	13.8	12.2	14.2	15.5	18.6	21.8	24.0	17.9

* calculated as the average of the mean daily maximum / minimum temperature available for the year (may differ from average of mean monthly values)

The lowest recorded temperature was -7°C in July 1959 and the highest recorded was 49.3°C in January 1939.



RPS

Figure 8 – Average Monthly Temperature

f:\jobs\a258c\600\figures\figures- word docs\fig 8 average monthly te

3.5.2 Rainfall

Published data from a number of BoM stations identified near the project area has been reviewed (a range of rainfall data represented in Appendix D). The BoM stations listed in Table 4 are in order of proximity, showing locality and quality of available data. The closest long term rainfall station to the site is Warramboo. Data gaps affect 5% of this record, and these were infilled to develop a representative monthly rainfall dataset for the project site, which is required for use in the subsequent hydrological analysis.

Table 4: Bureau of Meteorology Station Directory (data downloaded on April 2013 from http://www.bom.gov.au)

BoM Station	Station ID	Easting	Northing	Elevation (m AHD)	Location in relation to CIEP site (km)	% area of influence over mine lease boundary	Data Period		Approx. % Records Complete
							From	To	
Warramboo	018090	555691	6321714	89.0	5 km west	59%	Nov-1924	Current	95%
Kyancutta (Kyanbare)	018170	567816	6333024	97.0	13 km north	18%	Apr-1969	Dec-2011	94%
Kyancutta	018044	551787	6333809	57.0	15 km north west	23%	Jan-1930	Current	100%
Koongawa (Retawon)	018101	580831	6331007	170.0	21 km north east	0%	Aug-1951	Aug-2012	98%
Kyancutta (Billabowie)	018208	538149	6323017	60.0	23 km west	0%	Jul- 2005	Current	91%
Lock	018046	570177	6285530	147.0	37 km south	0%	Jan-1915	Current	94%
Mount Wedge	018056	514790	6295054	42.0	55 km south west	0%	Jul- 1884	Current	91%
Darke Peak	018024	612557	6296195	165.0	57 km south east	0%	Jul-1914	Current	99%

Figure 9 identifies the proximity of rainfall stations to the CEIP, along with the Thiessen polygons that define the area of influence of each station (i.e. the Thiessen polygon contains all points that are closer to the identified rainfall gauge than to the other nearby gauges). The three rainfall stations that have an area of influence extending across part of the project area are: Warramboo, Kyancutta and Koongawa (Figure 9).

- Warramboo station (018090) is the closest station being only 5km to the west of the CEIP. Warramboo station also provides a very good quality and time span of data, with records dating from 1924 to present, and with 59% of the project area lying within the influence of this station (notably including the proposed open pits).
- Kyancutta (Kyanbrae) station (018170) is located 13 km from the CEIP and also provides quality long term data, with 18% of the project area lying within the influence of this station.
- Koongawa (Retawon) station (018101) is located 21 km north east of the project area and has available data dating from 1951 and with 23% of the project area lying within the influence of this station.

To calculate the project site representative rainfall, the data available for the three stations above was applied to the Thiessen polygon influence coefficients (or weighting percentages, namely 59%, 18% and 23% as described above) calculated for each station. When there is a data gap in any of the three stations (see data completeness in Table 4), the weighting percentages in the Thiessen methodology are modified proportionally and applied to the stations where there is data. With this method it is possible to use the data from three rainfall stations closest to the site to define a complete data record of representative monthly rainfall across the project site, for use in hydrological analysis (See Appendix D for the whole set of generated rainfall)

Table 5 includes the statistical analysis of the monthly rainfall data for these stations, together with rainfall data of selected wet years for application to the subsequent hydrological analysis.

Table 5: Monthly Rainfall Statistical Summary

Warramboo Station 018090 - Total rainfall (mm)

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	12.6	16.1	14.3	20.1	34.2	42.9	45.1	43.2	33.7	26.2	19.8	20.1	330.9
Minimum	0.0	0.0	0.0	0.0	3.0	3.5	11.6	7.8	1.5	0.0	0.0	0.0	179.4
10 %ile	0.0	0.0	0.0	1.9	8.0	15.0	22.7	13.1	8.5	3.5	4.9	0.9	219.3
25 %ile	1.0	1.3	0.8	5.6	18.7	20.2	29.1	26.7	15.5	9.7	10.5	6.0	263.4
Median	4.6	9.7	8.4	13.6	30.3	36.0	40.9	43.5	30.8	22.6	17.2	15.0	323.6
75 %ile	14.5	21.8	21.8	27.9	42.9	59.0	58.4	56.7	41.8	37.0	25.1	25.6	382.2
90 %ile	33.2	39.4	38.0	46.3	67.9	80.4	71.6	72.8	71.1	54.0	40.9	49.2	429.2
95 %ile	42.1	58.6	51.6	56.4	75.2	91.7	80.3	78.2	78.6	66.4	49.9	67.2	460.1
Maximum	108.6	114.8	71.0	96.2	110.1	109.6	112.7	104.3	117.4	83.1	64.8	90.7	601.2
Year 1968	32.5	30.7	71.0	34.1	58.8	108.0	81.2	52.8	28.3	28.5	23.7	26.9	576.5
Year 1992	1.6	7.4	38.4	61.2	58.6	28.4	24.8	79.6	84.6	73.4	64.8	78.4	601.2
Year 1979	10.2	1.6	1.8	17.8	68.8	11.6	58.6	57.2	117.4	23.2	50	15.8	434
Year 2011	1.2	97	52.8	13.8	30.2	31.2	47.6	55.8	35.8	41.2	7.4	17.4	431.4
Year 2013	3.6	25.8	27.6	25.8	35	57.6							

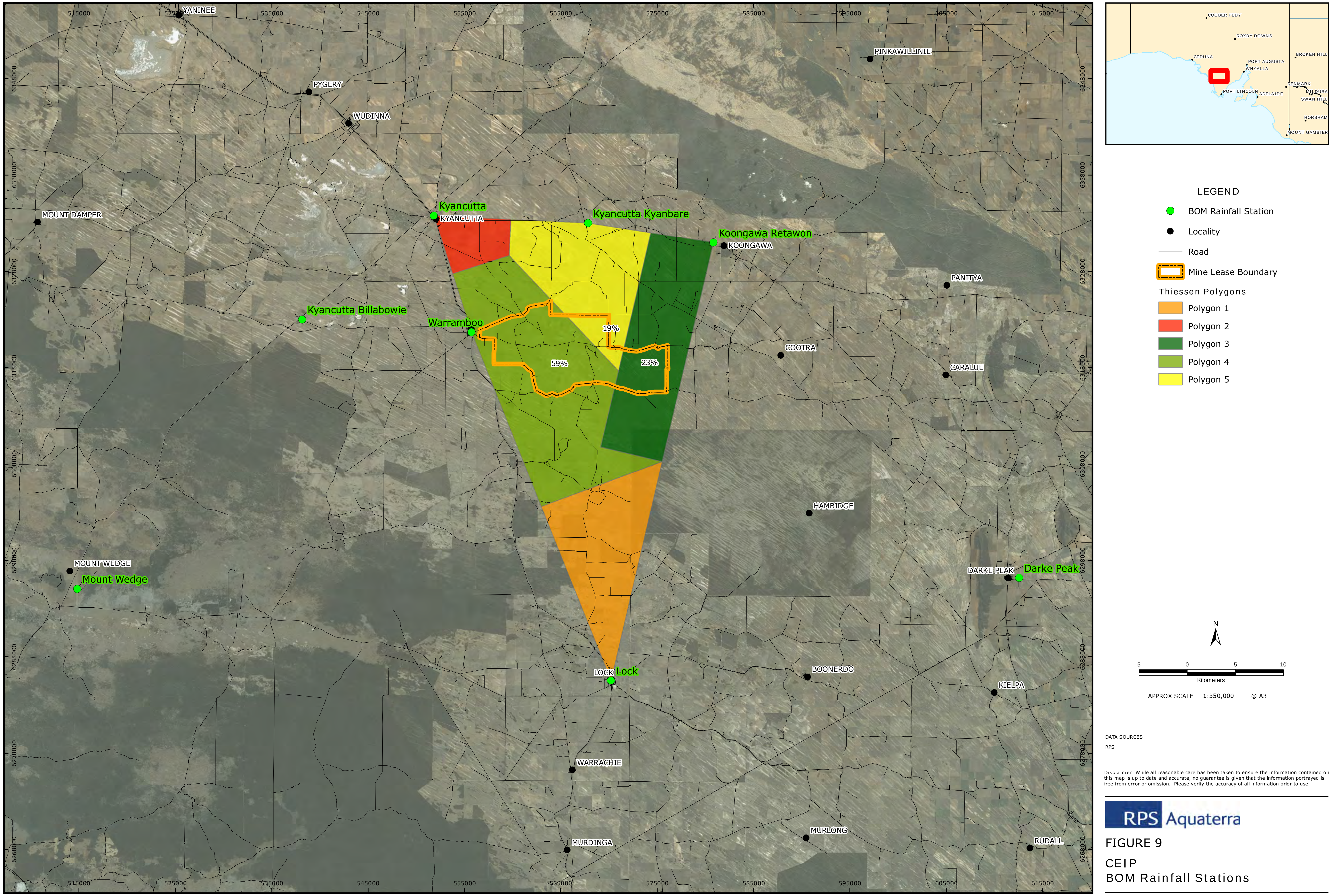
Kyancutta (Kyanbrae) Station 018170 - Total rainfall (mm)

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	15.4	11.9	16.6	18.1	30.8	34.5	39.0	36.1	33.7	27.4	21.9	18.0	307.7
Minimum	0.0	0.0	0.0	0.0	5.0	6.6	12.9	1.8	2.2	0.0	0.0	0.0	157.4
10 %ile	0.0	0.0	0.0	2.0	10.4	15.8	18.5	8.6	9.3	2.4	6.2	3.9	215.4
25 %ile	0.6	1.6	2.9	5.6	16.2	22.5	24.3	17.4	17.8	9.0	9.1	6.1	249.4
Median	6.0	6.6	8.8	12.0	27.1	29.2	39.0	34.8	28.6	19.0	14.6	11.1	280.8
75 %ile	17.5	13.1	25.0	28.3	40.2	42.2	54.2	50.6	44.6	48.5	22.1	22.2	365.7
90 %ile	34.3	25.4	51.4	38.4	54.0	71.8	59.1	68.4	68.6	56.3	44.7	32.1	395.2
95 %ile	53.1	42.6	53.7	55.6	64.3	74.9	61.1	71.8	78.2	61.5	58.0	58.3	485.9
Maximum	141	80.4	59.2	78.8	91.9	78.2	77.6	77.3	105.7	97	145.6	94.6	560.2
Year 1968													
Year 1992	0	6.8	38.8	55.6	44.8	24.2	18	59.4	75.6	85.4	57	94.6	560.2
Year 1979	0	3.4	5	13.3	68.4	8.8	41	49.5	105.7	22.9	76.2	8	402.2
Year 2011	1	80.4	52.4	7.6	29.8	24.6	40	37	25.8	51	5.8	9.4	364.8
Year 2013	2	26	49.2	16.2	14.8	54.8							

Koongawa (Retawon) Station 018101 - Total rainfall (mm)

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	15.1	14.4	17.9	21.6	38.6	43.1	43.4	40.9	37.5	26.3	19.6	20.3	343.4
Minimum	0.0	0.0	0.0	0.0	3.4	4.8	10.8	4.8	2.8	0.0	0.0	0.0	150.5
10 %ile	0.0	0.0	0.0	1.3	8.6	13.2	20.0	13.3	8.8	2.3	3.6	2.8	218.2
25 %ile	1.5	1.8	3.1	6.0	16.6	24.4	28.4	25.5	19.6	9.0	8.0	7.2	284.6
Median	6.4	7.6	10.7	14.2	32.3	37.4	39.4	37.1	30.6	20.0	16.4	13.4	336.8
75 %ile	18.1	20.7	23.5	27.4	49.1	54.7	57.1	56.8	55.3	45.7	25.8	23.8	393.8
90 %ile	33.5	34.1	47.6	47.4	78.8	85.2	67.5	69.0	74.1	56.0	40.0	54.0	448.3
95 %ile	42.0	62.0	60.4	65.2	90.2	88.6	71.4	75.3	83.4	61.5	47.7	59.5	548.6
Maximum	123.4	74.2	70.4	90.6	125.3	116.4	139.5	101.6	121	93.9	110.2	103.6	607.7
Year 1968	21.9	71.4	30.3	40.5	62	116.4	83.7	69.2	24.5	32.5	21.8	19.5	593.7
Year 1992	0.4	5.6	42.8	31.8	52.6	32.6	21.2	68.8	86	56.7	41.2	103.6	543.3
Year 1979	0.0	34.6	3.6	14.2	80.8	10.2	42.6	55	121	16.6	66.2	7.2	452.0
Year 2011	0.0	74.2	60.2	13	32	29.3	39	57.4	28.3	46	8		
Year 2013													

25 %ile indicates 25th percentile, or that 25% of rainfall observations fall below this amount. Median is 50 %ile.



DATA SOURCES
RPS

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Please verify the accuracy of all information prior to use.

RPS Aquaterra

FIGURE 9

CEIP
BOM Rainfall Stations

A225_001 Rev: A Produced: Loader Reviewed: Loader Date: 26/03/2012

Table 6 summarises the values of the representative monthly rainfall for the Project site calculated using the Thiessen Polygons methodology as previously explained, which have been used for calculating ponded volumes in section 4.

Table 6: Representative Monthly Rainfall

Representative Monthly Rainfall (mm) from Thiessen Polygons to Warramboo , Kyancutta and Koongawa Stations data													
Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	12.7	16.0	14.6	19.9	34.5	41.9	44.2	42.1	33.4	26.5	19.9	19.9	325.4
Minimum	0.0	0.0	0.0	0.0	3.0	3.9	11.6	7.4	1.9	0.1	0.0	0.0	171.3
10%	0.0	0.0	0.0	1.5	7.9	13.8	22.1	12.8	9.1	3.0	5.2	1.2	220.5
25%	1.0	1.8	0.7	5.9	17.5	20.6	29.2	27.7	15.5	9.3	10.1	6.1	263.9
Median	5.5	9.4	8.8	13.4	30.4	35.3	42.0	42.7	30.2	21.5	16.5	14.0	308.2
75%	15.4	22.0	22.5	27.9	44.6	57.0	54.9	55.2	43.1	40.7	24.3	24.8	383.4
90%	31.6	39.4	39.7	45.3	68.0	79.1	68.0	69.7	67.5	52.0	43.8	51.7	422.8
95%	43.0	52.7	51.6	53.7	77.8	86.0	78.3	75.5	77.0	66.7	49.8	66.8	456.5
Maximum	117.8	114.8	64.3	91.8	114.4	110.4	120.2	96.0	116.1	84.8	73.3	90.7	581.3
Year 1968	29.5	42.1	59.6	35.9	59.7	110.4	81.9	57.4	27.2	29.6	23.2	24.8	581.3
Year 1992	1.0	6.9	39.5	53.4	54.7	28.6	22.7	73.5	83.3	71.7	58.0	87.1	580.5
Year 1979	6.0	9.5	2.8	16.2	71.5	10.8	51.8	55.3	116.1	21.6	58.4	12.4	432.4
Year 2011	0.9	88.8	54.4	12.5	30.5	29.6	44.3	52.8	32.3	44.1	7.3	15.0	412.4
Year 2013	3.2	25.8	32.6	23.6	30.4	57.0							

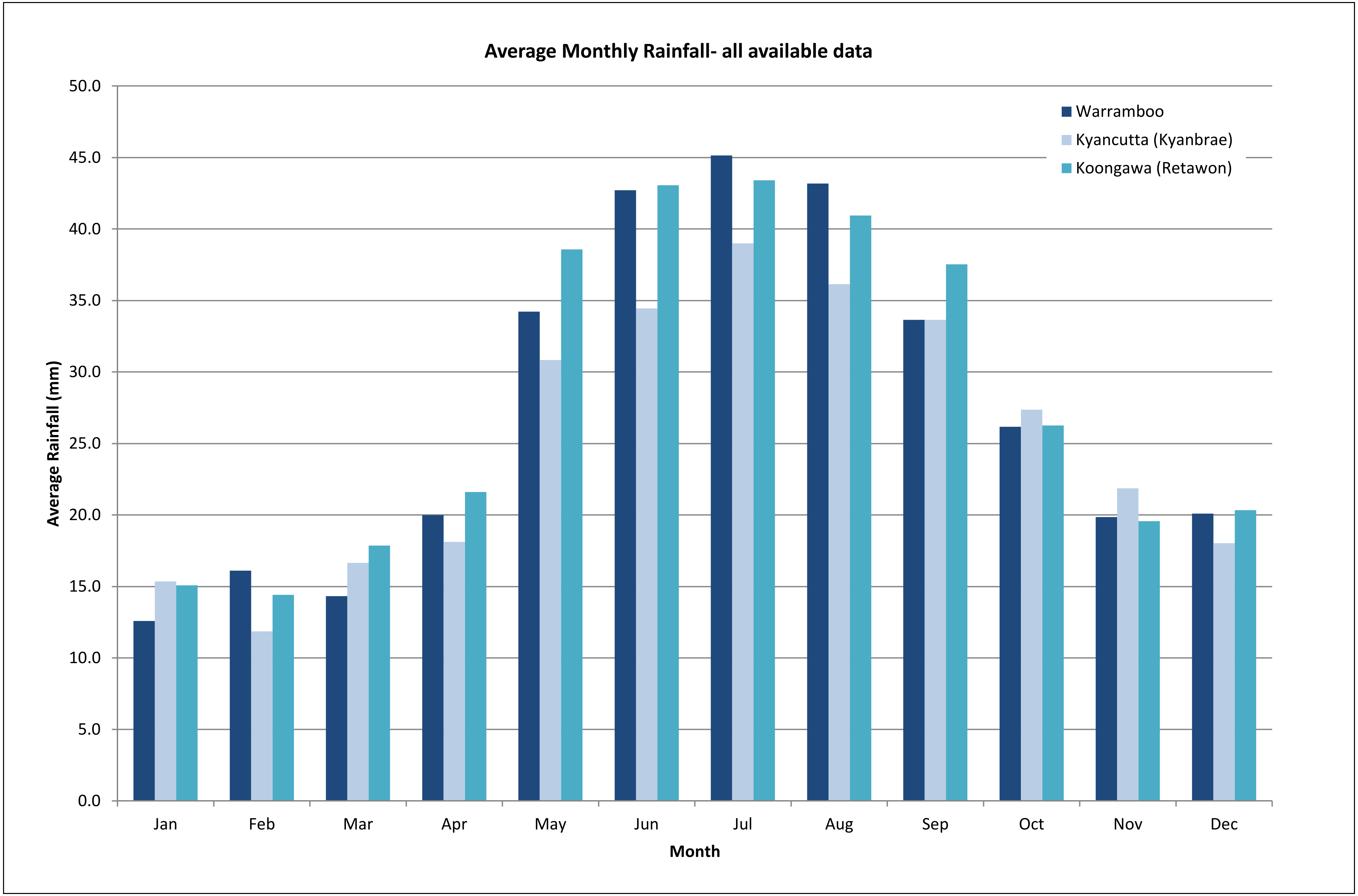
25 %ile indicates 25th percentile, or that 25% of rainfall observations fall below this amount. Median is 50 %ile.

Figure 10 compares the monthly average rainfall at the project area for the three stations closest to the CEIP site (i.e. stations with a non-zero influence coefficient indicated in Table 4).

The representative average monthly rainfall shows strong seasonality, with the wetter months being May to September, when about 60% of the total annual average rainfall is accounted.

Data from the notable wet years (1968, 1992, 1979 and 2011) and notably dry year (1957) will be used in subsequent hydrological analysis to quantify the ponded volumes for those drainage catchments affecting the mine area.

Although rainfall predominantly occurs in the winter months, major rainfall events statistically occur in the months of December, January and February, when local summer storms are common, causing intense daily rainfalls (see Figure 10 and Figure 11). The largest single rainfall event was recorded in February 1938 when 88.9mm of rain fell in 24 hours and 114 mm fell in a 72 hour period. This event had an annual recurrence interval of approximately 50 years when compared with the published Intensity-Frequency-Duration (IFD) data for the Project site (see Table 7).



LOCAL AVERAGE MONTHLY RAINFALL FIGURE 10

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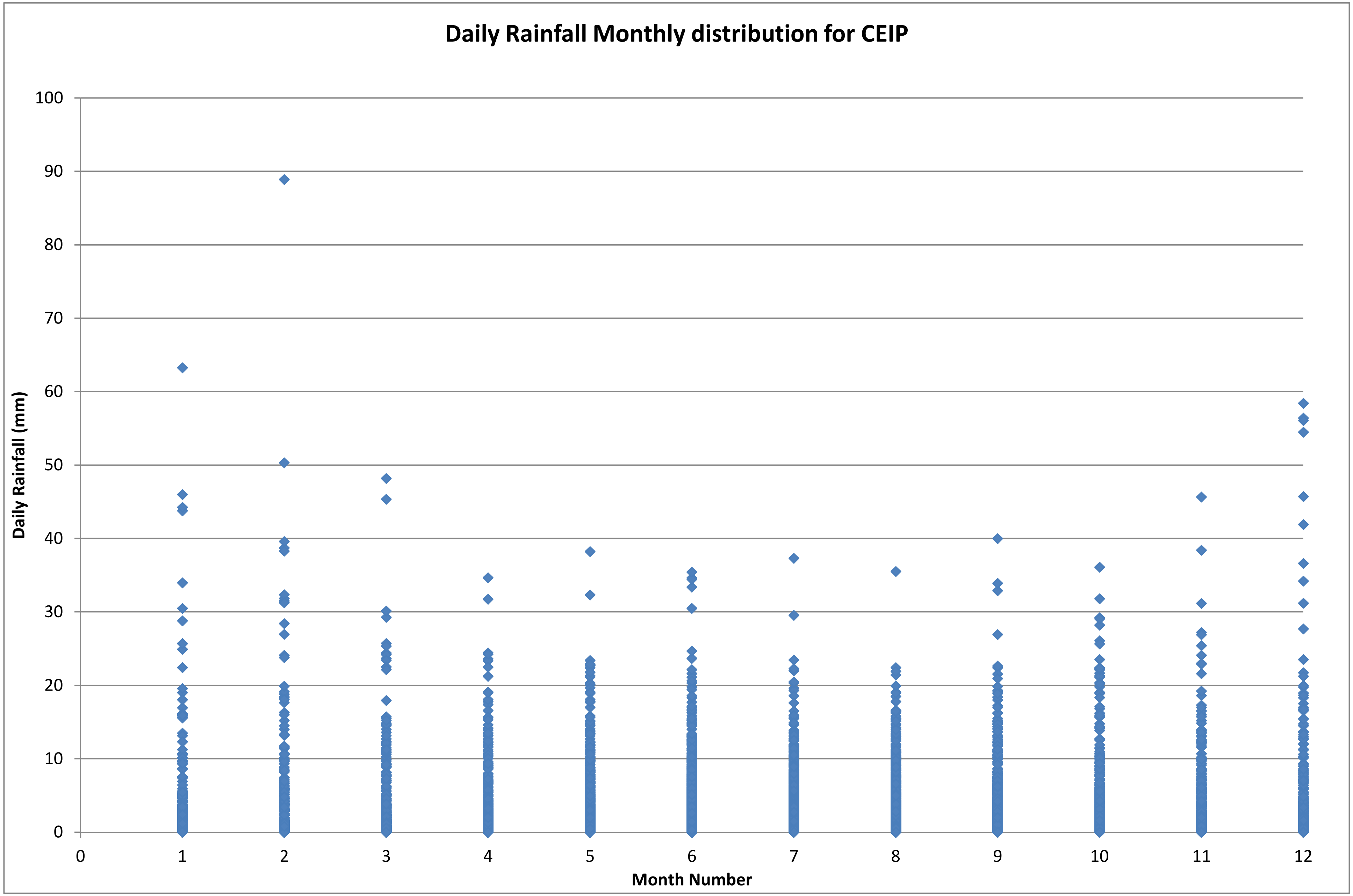
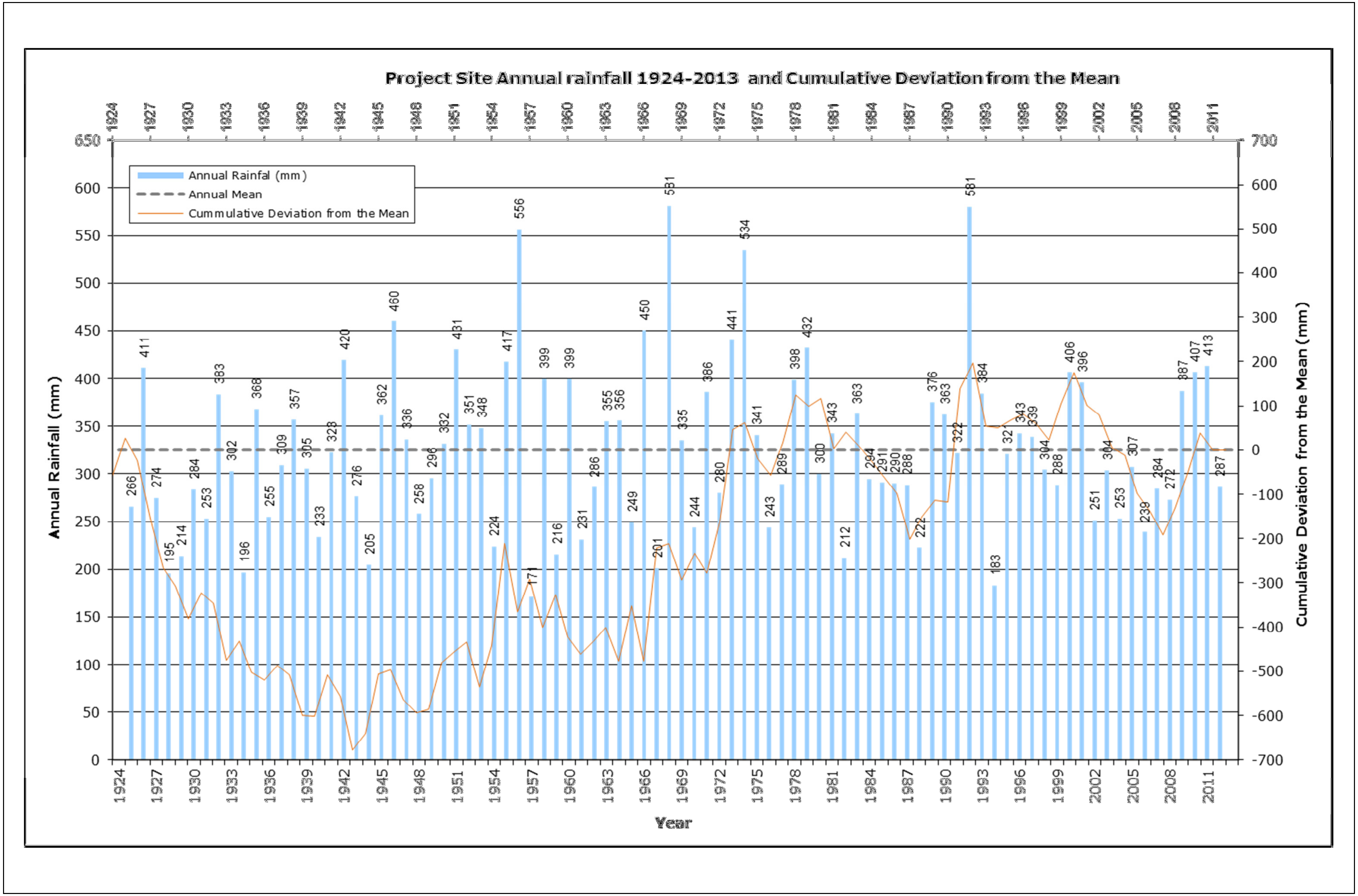

Daily Rainfall Monthly distribution for CEIP
Daily Rainfall (mm)
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
7
8
9
10
11
12
Month Number

Figure 12 presents the cumulative rainfall deviation (CRD), which can be used to identify extended periods of:

- persistent dry conditions (lower rainfall than average indicated by decreasing CRD slope) in the 1920's and 1930's, most of the 1980's, and most of the first decade in the 2000's;
- persistent wet conditions (higher rainfall than average indicated by increasing CRD slope) for a short period in the mid 1950's, and then for about 10 years from the mid 1960's to the mid-1970's, again in the late 1980's and early 1990's, and most recently in the 2010-11 period;
- extended periods of more or less average rainfall for much of the 1940's, early 1950's and early 1960's, and much of the 1990's (apart from those wet and dry periods mentioned above).

Figure 12 shows the high variability of the recorded annual rainfall, with wet and dry cycles and sub-cycles difficult to predict, ranging from 5 to 15 years of duration, with the highest recorded annual rainfall more than three times the lowest recorded and no overall tendency shown in the last century. The most recent wet cycle started in 2008 and continues in 2013.



PROJECT SITE ANNUAL RAINFALL AND CUMULATIVE DEVIATION FROM MEAN FIGURE 12

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3.5.3 Rainfall Intensity-Frequency-Duration

Rainfall Intensity-Frequency-Duration (IFD) data for selected Annual Recurrence Interval (ARI) events can be used in probability analysis and also in hydrological analysis. The IFD data summarised in Table 7 was downloaded from BoM, based on the coordinates of the Warramboo station.

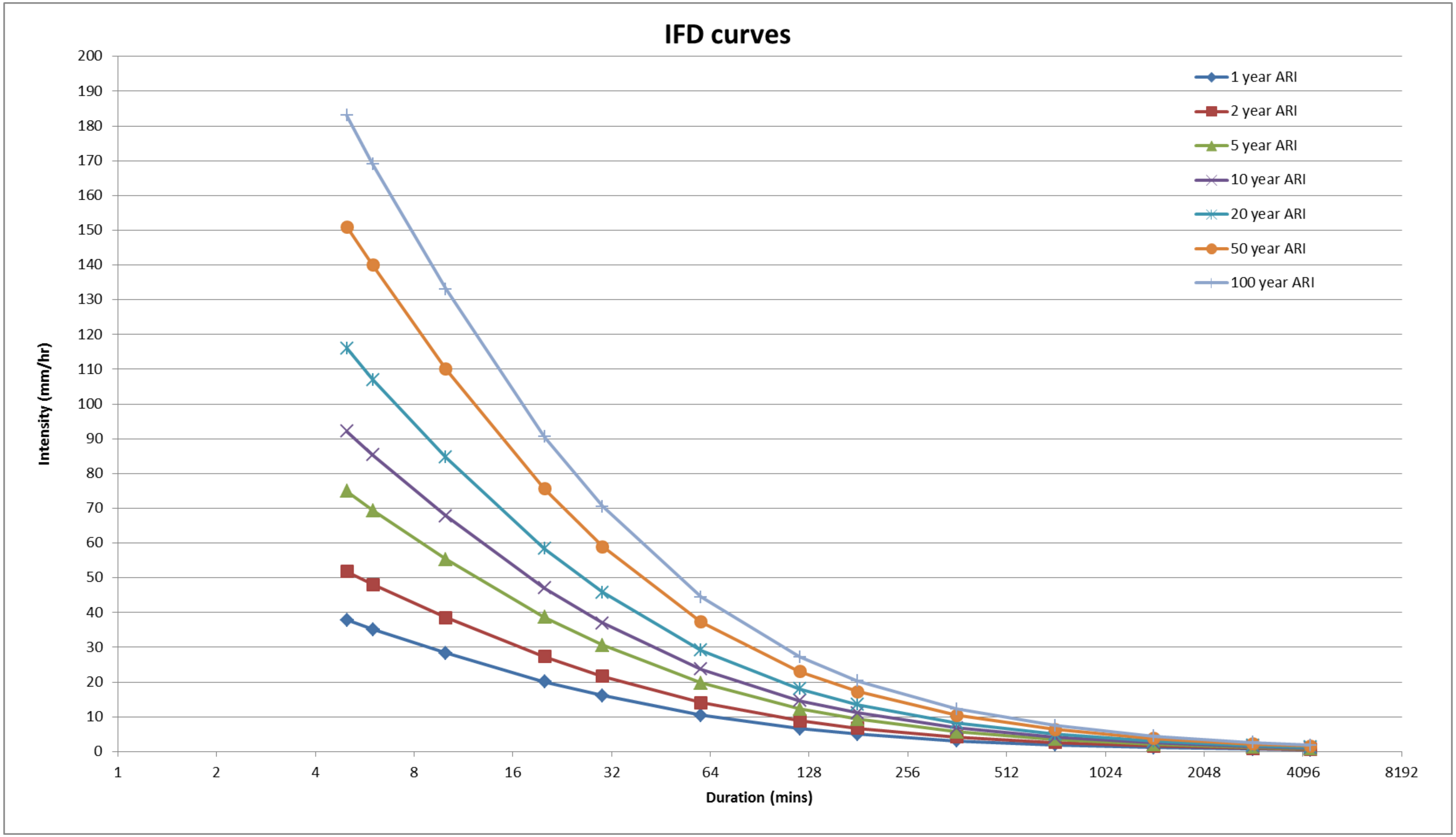
Table 7: Rainfall intensity in mm/hour for various durations and Average Recurrence Interval

AVERAGE RECURRENCE INTERVAL							
DURATION	**1 Year**	**2 years**	**5 years**	**10 years**	**20 years**	**50 years**	**100 years**
5Mins	37.9	51.8	74.9	92.2	116	151	183
6Mins	35.2	48.1	69.4	85.4	107	140	169
10Mins	28.3	38.6	55.3	67.8	84.7	110	133
20Mins	20.1	27.3	38.7	47.1	58.4	75.6	90.6
30Mins	16.1	21.7	30.6	37	45.8	59	70.5
1Hr	10.5	14.1	19.7	23.7	29.1	37.3	44.4
2Hrs	6.64	8.9	12.3	14.7	18	23	27.2
3Hrs	5.04	6.75	9.27	11.1	13.5	17.2	20.3
6Hrs	3.13	4.18	5.7	6.8	8.26	10.5	12.3
12Hrs	1.93	2.58	3.5	4.15	5.04	6.35	7.47
24Hrs	1.18	1.56	2.11	2.5	3.03	3.81	4.48
48Hrs	0.689	0.912	1.23	1.45	1.76	2.21	2.59
72Hrs	0.49	0.651	0.871	1.03	1.24	1.56	1.82

Source: Bureau of Meteorology, Australian Government

The rainfall intensity may be plotted against duration for selected ARIs, which produces curves with a negative gradient (Figure 13). The probability of any event (i.e. ARI) can be interpolated from these curves by plotting a point on the chart which corresponds to the observed intensity and duration.

For example, for a selected ARI (or probability of occurrence), more intense rainfall rates are associated with shorter duration events. However, for a given duration event, the rainfall intensity increases with increasing recurrence interval (i.e. intensity is higher for less likely events or higher ARIs).



IFD curves
Intensity (mm/hr)
Duration (mins)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
1
2
4
8
16
32
64
128
256
512
1024
2048
4096
8192
1 year ARI
2 year ARI
5 year ARI
10 year ARI
20 year ARI
50 year ARI
100 year ARI

3.5.4 Evapotranspiration

Evaporation is a term applied to estimating evaporation from open-water surfaces, and is usually based on Pan Evaporation data, sometimes with a reduction factor applied (to account for pan measurement issues) when estimating evaporation from mine water management ponds. The closest pan evaporation site is at Kyancutta (about 13km from the site), with summary data presented in Table 8, along with (BoM-calculated) evapotranspiration.

Evapotranspiration (ET) is a collective term (i.e. distinct from Pan Evaporation) for the transfer of water (vapour) to the atmosphere from vegetated and/or un-vegetated land surfaces. ET is a large component of the water balance of a catchment, with around 90% of the precipitation that falls on the Australian continent being returned through ET to the atmosphere (BoM, 2001). ET is affected by climate, availability of water and vegetation. ET is defined by published BoM Climate Atlas maps for application to rainfall-runoff and other hydrological processes. The following definitions apply (BoM, 2001):

- Actual ET is the rate of evapotranspiration expected broadly across the landscape (e.g. where the water available is not unlimited and is typically constrained by the rainfall).
- Areal Potential ET is the rate of evapotranspiration that is not constrained by water availability, and is conceptually the upper limit to actual ET applied in most rainfall-runoff studies.
- Point Potential ET can be used as an estimate of the rate of evaporation from shallow lakes; for example, it could be applied to the ponding that develops in the swales around the project area (although further reduction factors may need to be applied to account for very high salinity).

Table 8: BoM Climate Atlas Monthly ET, Kyancutta Pan Evaporation and Warramboo Rainfall

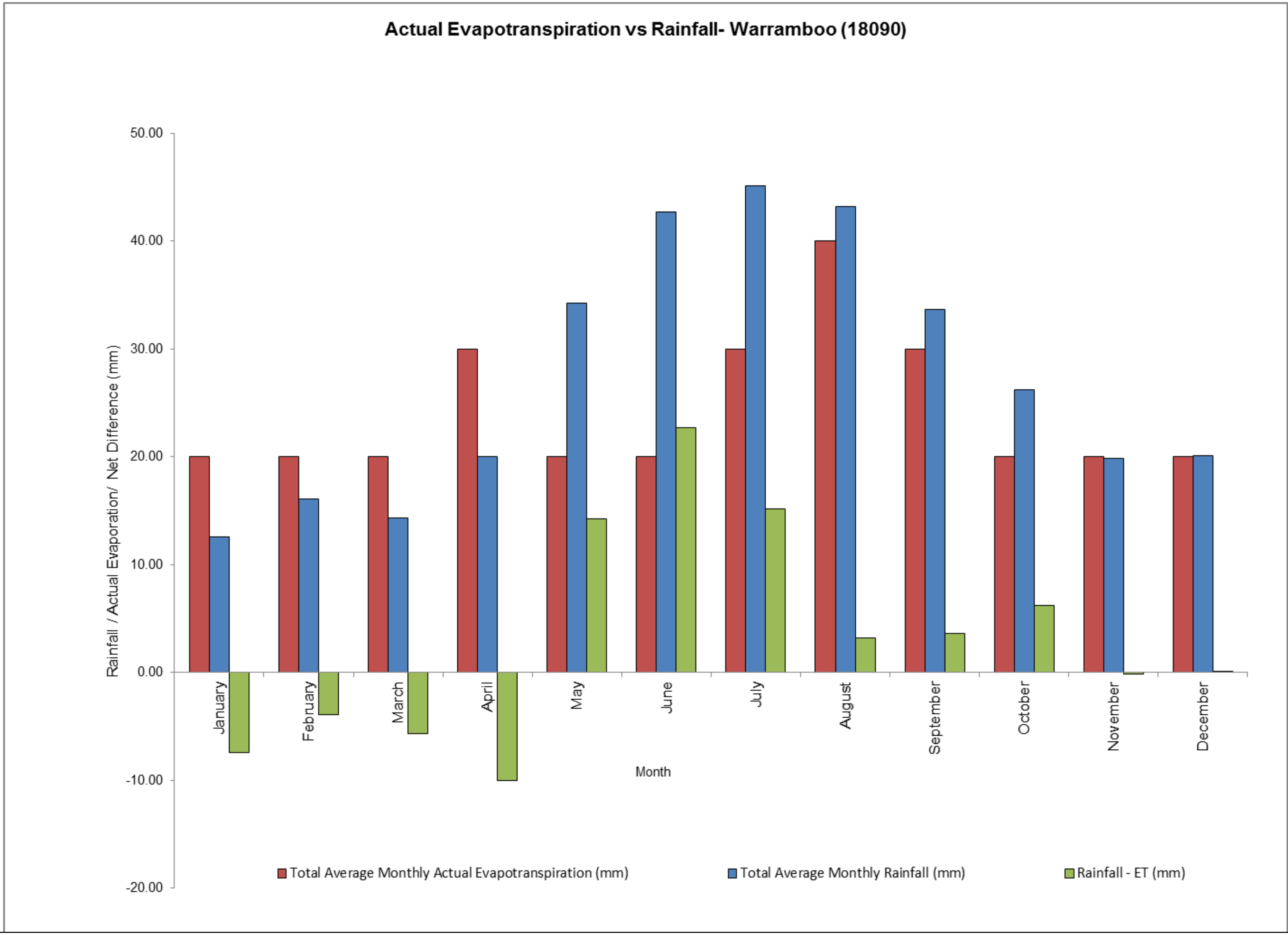
Month	Actual ET (mm)†	Point Potential ET (mm) †	Areal Potential ET (mm) †	Kyancutta Pan Evaporation (mm)*	Warramboo Rainfall (mm)[x]
Jan	20	240	180	199	12.6
Feb	20	210	135	159	16.1
Mar	20	175	120	144	14.3
Apr	30	110	75	95	20.1
May	20	75	45	64	34.2
Jun	20	45	45	46	42.9
Jul	30	50	45	49	45.1
Aug	40	70	60	66	43.2
Sep	30	110	75	93	33.7
Oct	20	170	120	135	26.2
Nov	20	210	150	163	19.8
Dec	20	220	165	188	20.1
Annual	290	1685	1215	1407	330.9

†: BoM climatological Atlas 2001

* Source: Kyancutta 18044 SILO Station

[x] Source: Warramboo 18090 BoM Station

Table 8 shows that potential evaporation (e.g. from ponded areas) is significantly in excess of rainfall for the majority of the year, except during June and July, when rainfall and potential evapotranspiration are roughly equal. Actual evapotranspiration (at the broad landscape scale) is fairly constant throughout the year, slightly higher in April and from July through to September, with a peak of 40mm in August (Table 8 and Figure 14).



AVERAGE MONTHLY RAINFALL VS ACTUAL EVAPOTRANSPIRATION FIGURE 14

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4 Surface Drainage Analysis (Pre-Mining)

4.1 Rainfall Infiltration and Swale Ponding

As described in Section 3, the swales in the base of low lying areas are known to be partly filled to shallow depths for several weeks to a few months during most winters. The filling process occurs during winter because rainfall exceeds evapotranspiration, meaning that there is water available for infiltration and subsequent recharge to the sub-surface. Summer storm rainfall events could also cause minor ponding, but this is typically very short-lived (order of days).

The swales are isolated by intervening dunes and the small areas of ponding are not connected. This means that the swale water volumes within the proposed mine lease area need to be evaluated and managed such that they do not impact on mining activities and facilities. The method adopted for evaluating the hydrology of these swales was development of a water balance model.

4.2 Central Eyre Water Balance (CEWB) Model

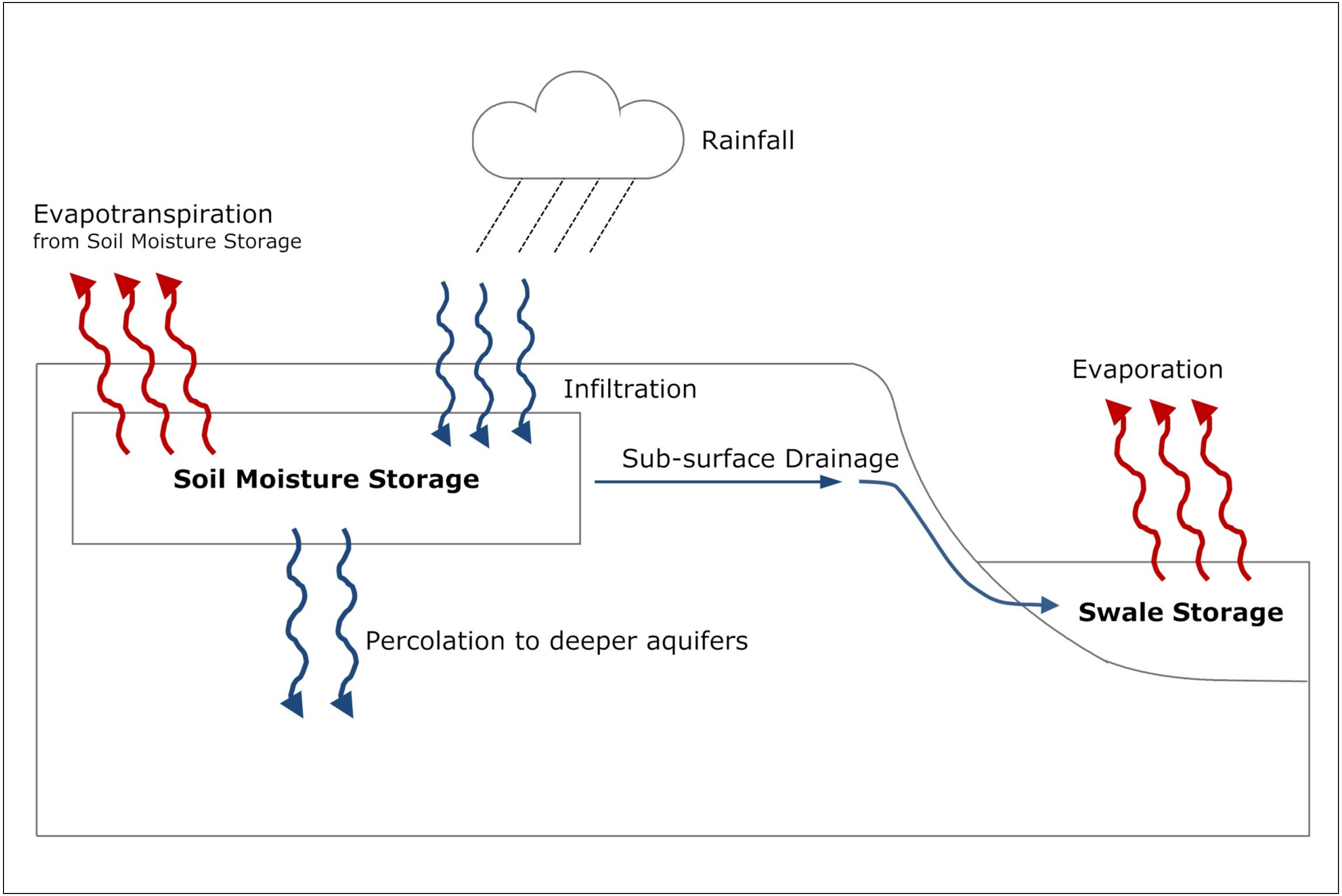
Several swales that are subject to ponding have been identified within the mine boundary as shown in Figure 7. Specific features referred to in the analysis of mine development impacts are as follows:

- Swales S1, S2 and S3 are contained within catchment CH3, which sits outside the proposed mine lease area.
- Swales S4 to S23 are scattered within the low lying areas of the CH2 catchment, close to the proposed open pit, and form the natural end-point for CH2 drainage. These were adopted for model calibration.
- The mine lease boundary within CH1 intersects a number of swales and this area is isolated from all mine site infrastructure except for the proposed Integrated Waste Landform (IWL).

A catchment water balance model (monthly balance) has been developed based on the work of Holtan (1961) and applied to the entire contributing catchment CH2 to estimate the swale ponded volume. This is an approximate approach that assumes that drainage on the entire catchment CH2 reports to the identified swales S4 to S23, mostly via sub-surface drainage processes. There is no indication of any surface water storage in other inter-dunal areas outside the low lying areas. The results from calibration in CH2 were applied to sub-catchments within CH1 for analysis of potential IWL impacts along the southern mine lease boundary.

The Central Eyre Water Balance (CEWB) has been developed for the purposes of this hydrological study to calculate ponded volumes in swales and low lying areas within the Mine Lease. The hydrologic processes considered in the CEWB model effectively calculate the catchment water balance at a monthly time step. The key aspects are illustrated in the Figure 15 schematic and described below:

- Rainfall infiltrates through the surface, increasing the Soil Moisture Storage (SMS) as it fills up the voids (conceptually to a depth of 5,000 mm), minus a portion that is lost via evapotranspiration (either directly from surface ponding or from the SMS).
- The water stored in the SMS after evapotranspiration either percolates to deeper aquifers or drains to low lying areas, resulting in swale ponding. The drainage occurs via sub-surface processes that may be augmented by local runoff in the low permeability parts of inter-dunal floors that are near saturation and/or have near-surface water tables. The volume of water that percolates to deeper water tables (i.e. do not intersect with the land surface) can be considered to be lost from the catchment.
- The percolation ratio to deeper aquifers (ratio of deep percolation to the total water available in the SMS) is an exponential function of the soil moisture, soil porosity and saturated hydraulic conductivity (Holtan 1961).
- As the SMS approaches its maximum capacity, the percolation ratio decreases and more sub-surface drainage to the swale storage is generated.



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CEWB MODEL SCHEMATIC FIGURE 15

For a given monthly time step the water balance equation is:

Rainfall - Effective Evapotranspiration = Percolation to deeper aquifers + Sub-surface Drainage

The water balance is calculated using a percolation ratio:

Percolation volume = (Rainfall - Effective Evapotranspiration) * Percolation ratio.

Soil moisture storage is the water available in the upper 5,000 mm of the soil profile after evapotranspiration and varies between 0% and the soil porosity (when soil is totally saturated). The soil porosity has been assessed for the three different types of soils encountered within the project site, using published typical soil porosity values for each soil type: 15% for medium permeability soils, 10% for low permeability soils and 3.5% for very low permeability soils (Carter & Bentley, 1991).

The calculated percolation ratios are high, given the occurrence of soils with medium permeability, effectively meaning that 95% to 100% of the infiltrated water percolates to deeper aquifers. See Appendix E for details of calculated percolation ratios.

In the CEWB model, Effective Evapotranspiration is calculated by applying a factor of 0.67 to the Areal Potential Evapotranspiration. This factor was derived from the maximum ratio of Actual ET to Areal Potential ET for July and August data (i.e. 30mm/45mm= 0.67 for July and 40mm/60mm= 0.67 for August – see Table 8). Effective Evapotranspiration is also limited to the water availability within the catchment, which is the sum of the rainfall, SMS and the swale ponded volume.

The calculated Effective Evapotranspiration used in the model can be seen in Table 9

Table 9: Calculated Effective Evapotranspiration used in CEWB model

Month	Calculated Effective ET (mm)
Jan	121
Feb	90
Mar	80
Apr	50
May	30
Jun	30
Jul	30
Aug	40
Sep	50
Oct	80
Nov	101
Dec	111

When the balance of the SMS is positive, sub-surface drainage is generated, increasing the swale water storage and the balance is carried forward to the next month in a cumulative effect. When the model predicts a negative value (e.g. due to drainage and/or infiltration exceeding the residual storage), the SMS is set to zero. This means that the model effectively drains to zero storage every summer, consistent with observations.

4.3 CEWB Model Calibration to 2013 Data

The CEWB model was applied to the existing (pre-mining) conditions for its calibration, using data on ponding gathered during winter 2013 for CH2 swales. The accumulated rainfall until July 2013 was 237mm, compared to the average accumulated rainfall until July of 185mm. Figure 7 shows the identified swales in the project area where water is known to pond regularly in the winter months, based on aerial photograph analysis. The extent and storage volume of each swale (Table 10) has been calculated from the LiDAR topography for the site (0.1m contour intervals). Swales 1, 2 and 3 are outside the limits of the project site and have not been used for the calibration of the model.

In 2013 a wet June and July with over 55mm of rain brought the ponded levels up to 285 ML (calculated value by the CEWB model, see Figure 16) which is about 20% of the maximum storage capacity (see maximum storage volume column in Table 10) within the Mine Lease Boundary. The ponded volumes predicted by the CEWB model are benchmarked to the measured ponded volumes as per survey in July 2013, which is 233 ML (see measured storage volume- July 2013 column in Table 10).

See Appendix E for further details on the model calibration.

Figure 16: 2013 Ponded Volumes at Swales within the Project Boundary (CEWB model calibration)

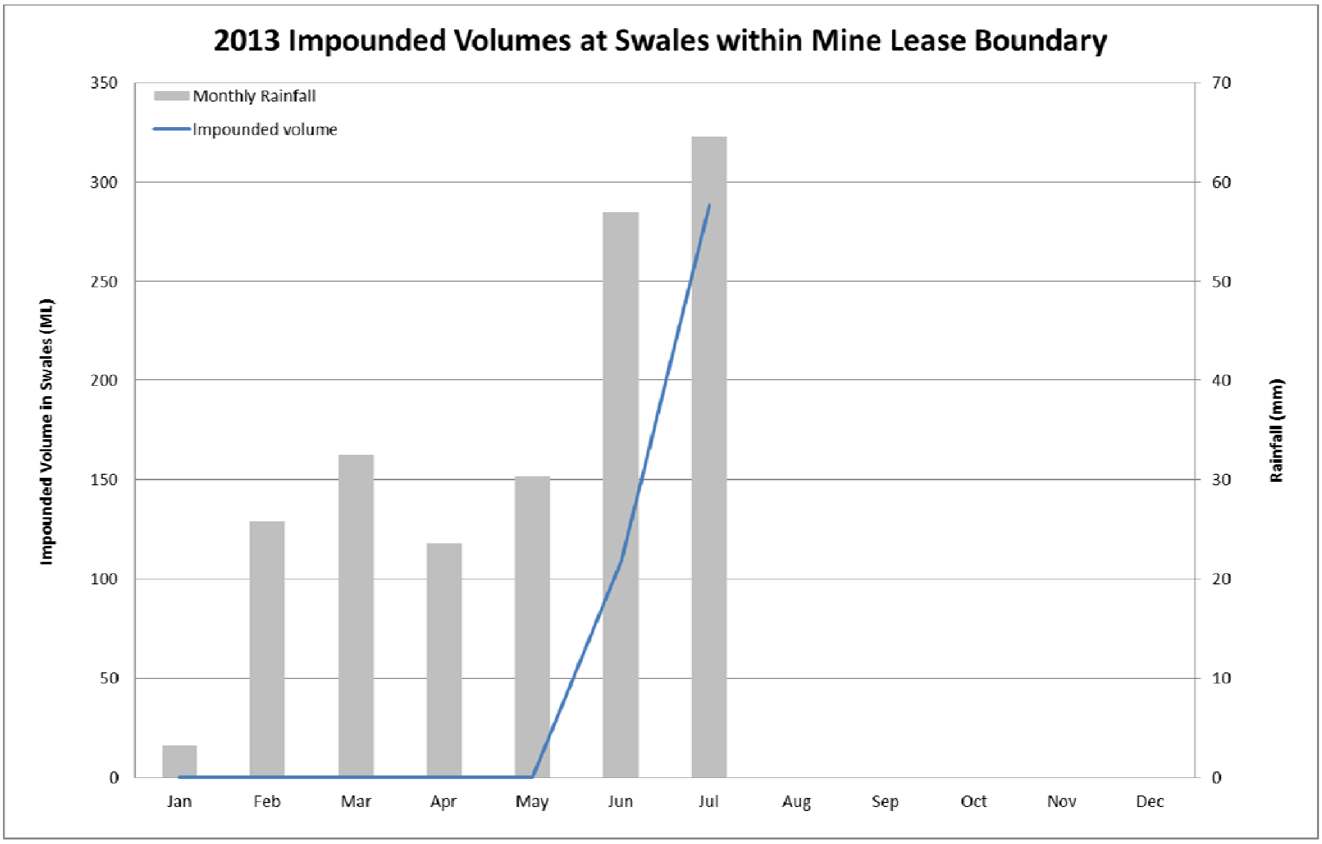


Table 10: Swale hypsographic data (level-area-volume) and CEWB calibration data (2013)

Swale	Minimum Bed Level (m AHD)	Maximum expected ponding Level (m AHD)	Maximum Water Surface Area (ha)	Maximum Water Storage Volume (ML)	Measured Water Level - July 2013 (m AHD)	Measured Water Surface - July Area 2013 (ha)	Measured Storage Volume -July 2013 (ML)
1*	61.92	65.94	37.42	856	Not Measured	Not Measured	0
2*	63.06	64.87	1.81	19	Not Measured	Not Measured	0
3*	63.33	64.44	3.46	22	Not Measured	Not Measured	0
4	62.94	64.41	2.67	23	Not Measured	Not Measured	0
5	61.49	63.56	2.20	27	Not Measured	Not Measured	0
6	63.09	66.03	5.36	92	Not Measured	Not Measured	0
7	63.30	65.18	2.18	24	Not Measured	Not Measured	0
8	63.75	65.25	4.31	38	Not Measured	Not Measured	0
9	61.20	63.23	9.87	117	62.27	4.02	25
10	61.73	63.03	8.45	64	62.51	7.06	32
11	61.72	63.80	20.53	249	Not Measured	Not Measured	0
12	62.31	64.50	1.27	16	62.74	0.30	1
13	62.37	64.90	7.32	108	64.90	7.32	108
14	61.38	62.96	3.09	28	62.96	0.43	4
15	62.10	63.71	1.24	12	Not Measured	Not Measured	0
16	62.45	65.05	21.85	202	63.28	6.06	18
17	62.36	63.72	8.65	69	63.04	4.77	19
18	61.77	62.83	2.06	13	62.33	0.77	3
19	61.83	62.67	0.71	3	62.67	0.71	3
20	62.08	63.27	16.96	118	62.70	3.76	14
21	62.22	64.04	7.17	63	62.96	1.91	7
22+	72.48	76.33	0.14	3	Not Measured	Not Measured	0
23+	77.01	79.47	0.55	8	Not Measured	Not Measured	0
		TOTAL	**169**	**2,175**		**37.13**	**233**
TOTAL in Mine Lease Boundary (Swales 4-23)			**127**	**1,277**		**37.13**	**233**

* indicates outside the Mine Lease Boundary; + indicates swales situated above low lying areas

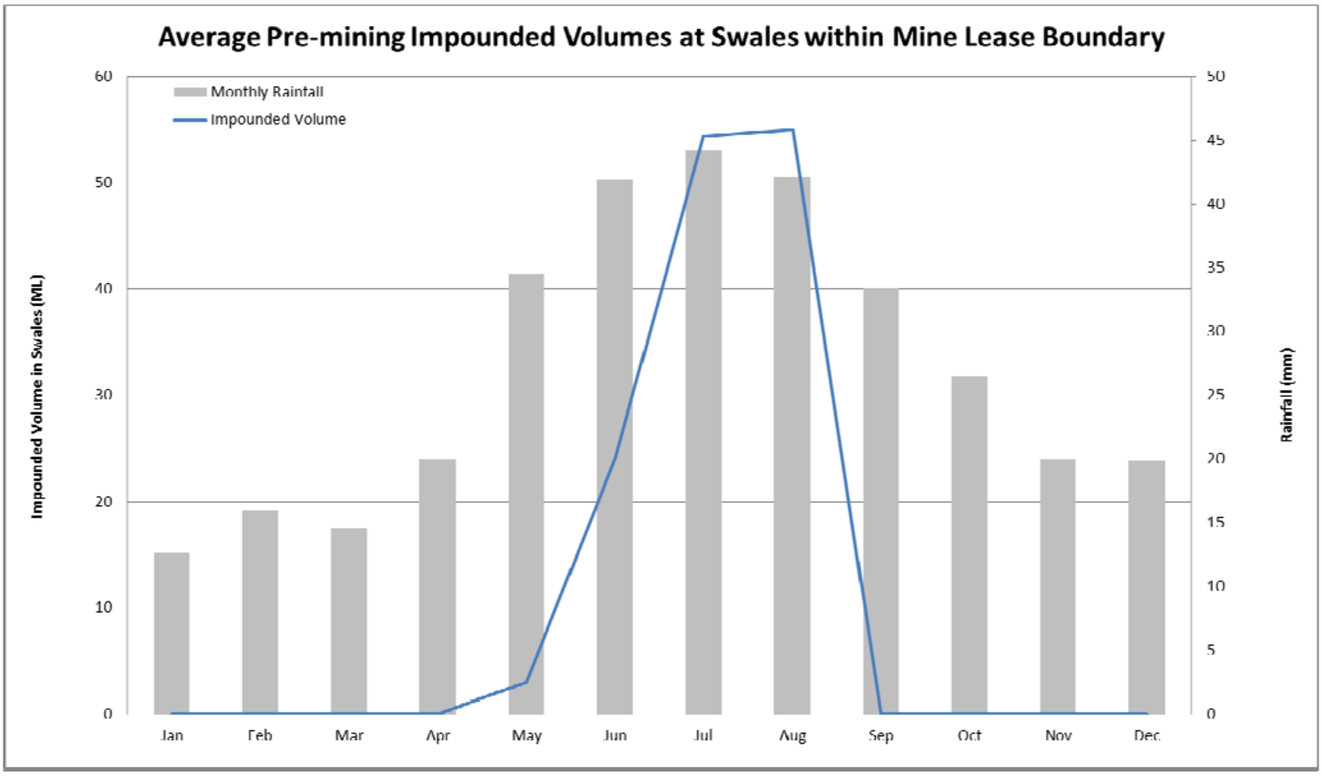
The accuracy of the swale volumes calculated and the calibration of the CEWB model relies on the accuracy of the swale survey and subsequent correlation with the digital elevation model provided.

4.4 CEWB Model applied to historical rainfall (pre-mining) within CH2

4.4.1 Average Rainfall Year

Applying the average monthly rainfall to the CEWB model indicates a predicted average year (325mm) ponded volume of just above 55ML occurring over July and August (Figure 17). See Appendix E for the model results.

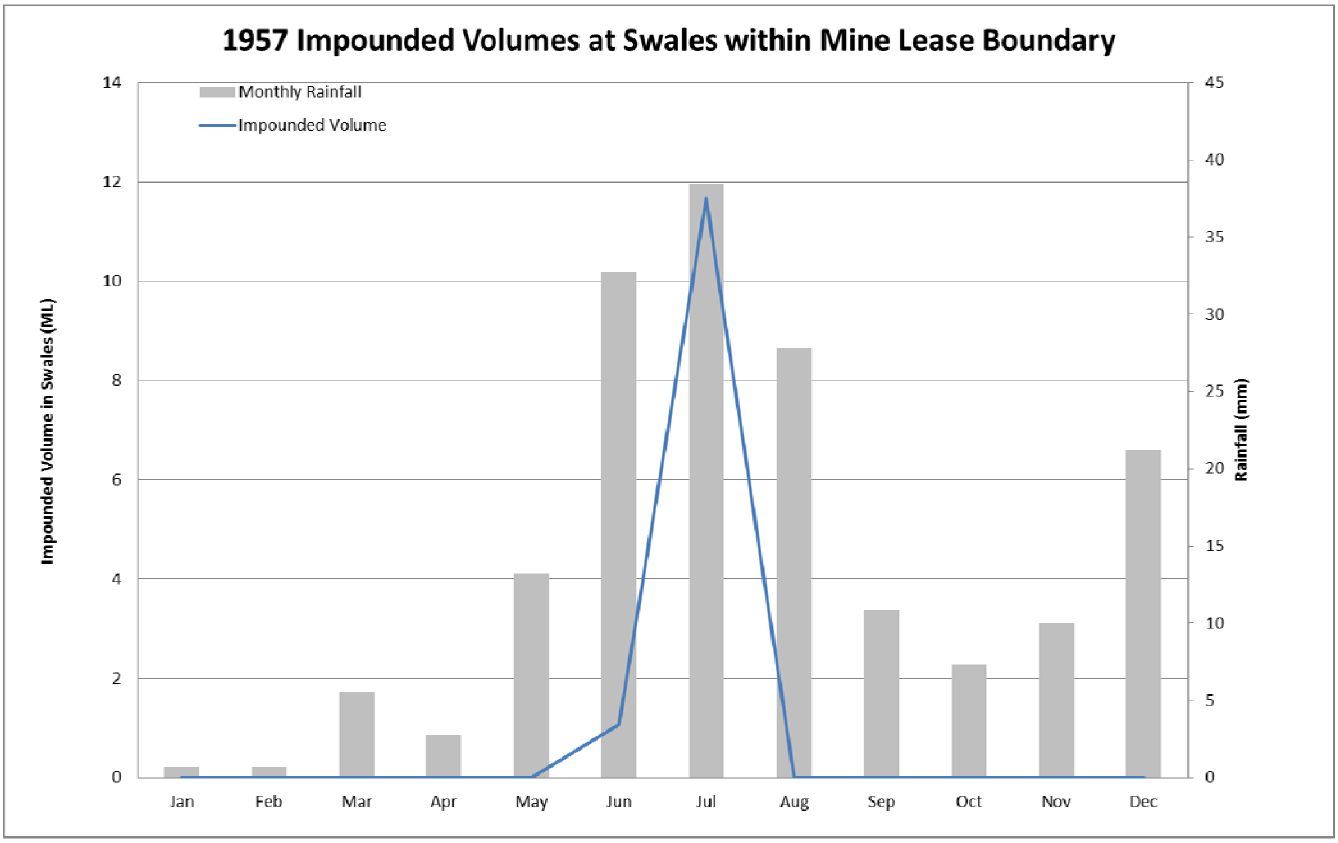
Figure 17: Average Pre- Mining Ponded Volumes at Swales within the Mine Lease Boundary



4.4.2 Minimum annual Rainfall Year – 1957

The lowest annual rainfall at the project site was in 1957, with a total annual of 171mm, most of it in June, July and August. The CEWB model predicts a maximum ponded volume of less than 12 ML in July (Figure 18) for all the swales within the Mine Lease boundary.

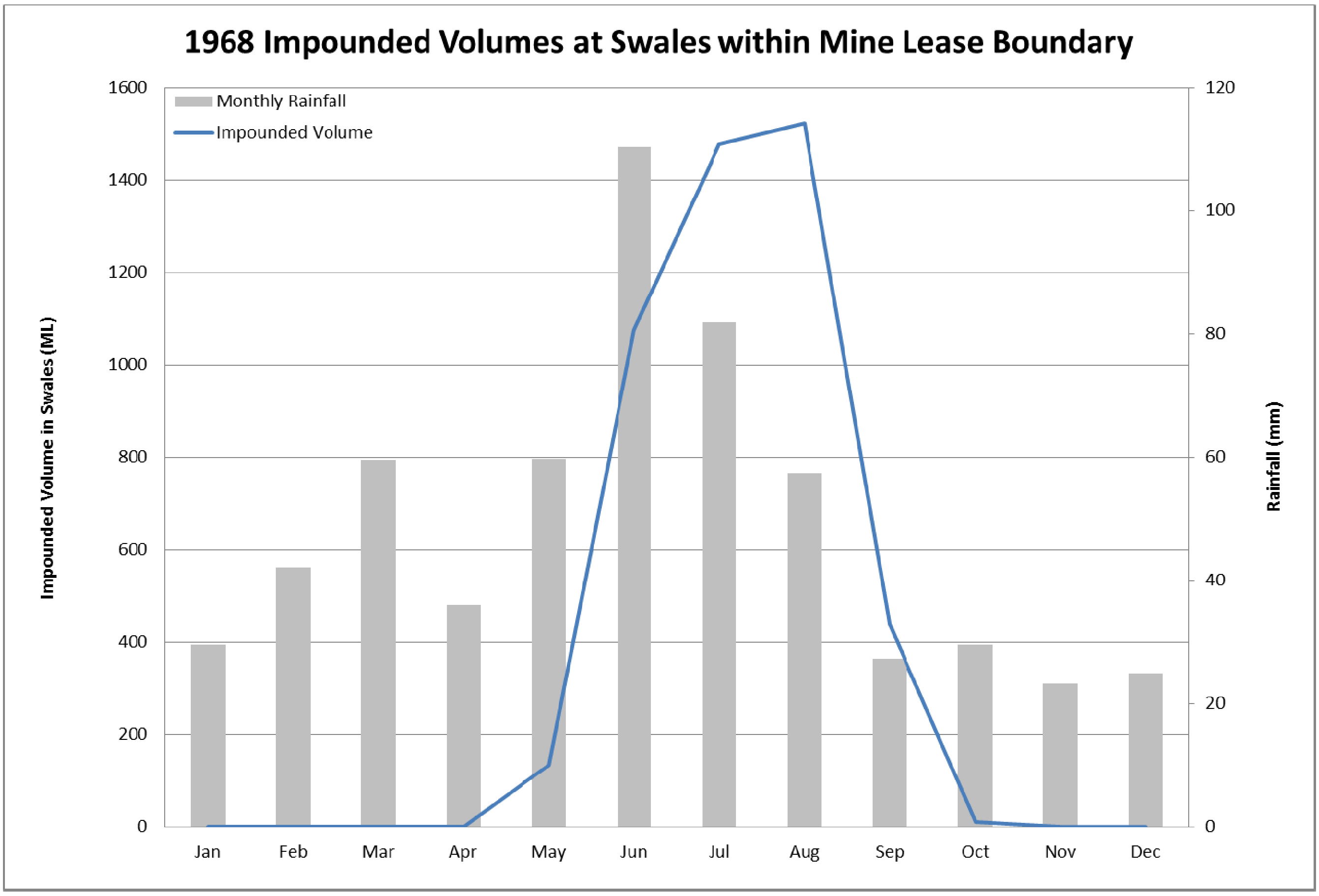
Figure 18: 1957 Ponded Volumes at Swales within the Mine Lease Boundary



4.4.3 Maximum Annual Rainfall Year – 1968

The highest annual rainfall at the project site was in 1968, with a total annual of 581mm and with 309mm over the period May to August. The CEWB model predicts a maximum ponded volume of about 1500ML in August (Figure 19), due to high winter rainfall and associated low winter evaporation.

Figure 19: 1968 Ponded Volumes at Swales within the Mine Lease Boundary

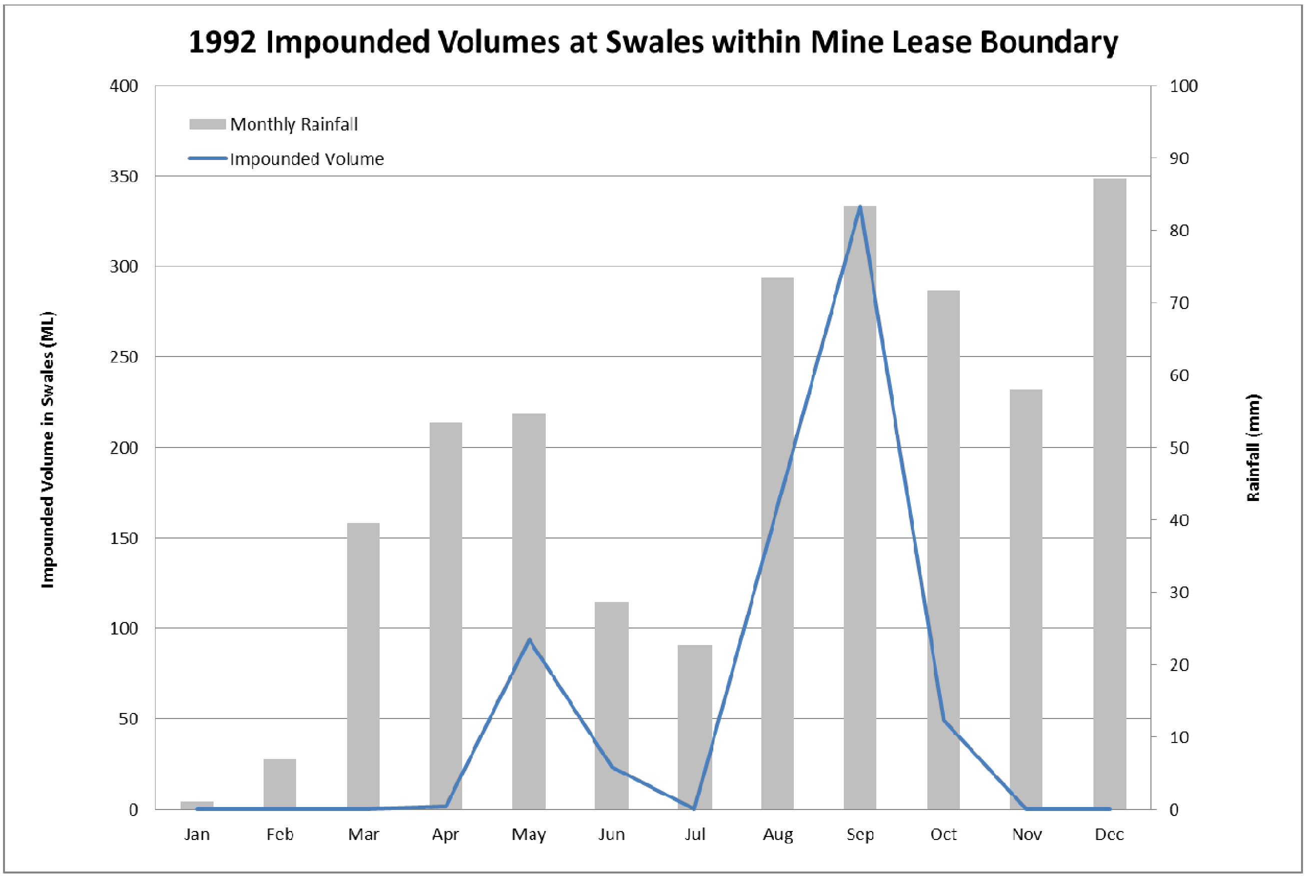


The predicted CEWB model volume for 1968 (Figure 19) would have completely filled the maximum swale storage volumes (Table 10), based on analysis of aerial photograph and Lidar-based hypsographic information and matching the field observations of maximum historical ponding. Under this scenario the swales would have still remained unconnected to each other.

4.4.4 High Annual Rainfall Year - 1992

The second highest annual rainfall year was 1992, with a total annual of 580 mm, and with a wet spring and summer (rainfall exceeding 70mm is recorded in each of the months of August, September and December). In this case the CEWB model predicts a maximum ponded volume of 335ML (Figure 20), which is about 25% of the maximum capacity of the swales. The main difference compared to the maximum ponding year of 1968 is the seasonal distribution of the 1992 rainfall. In 1992, there was low rainfall in June and July when there is also low effective evapotranspiration, but high rainfall in autumn, spring and summer, when the higher evapotranspiration reduces the ponded volumes. As noted for other years with high summer rainfall months (like 2011), the 87mm of rainfall in December 1992 is predicted to have not produced any ponding.

Figure 20: 1992 Ponded Volumes at Swales within the Mine Lease Boundary

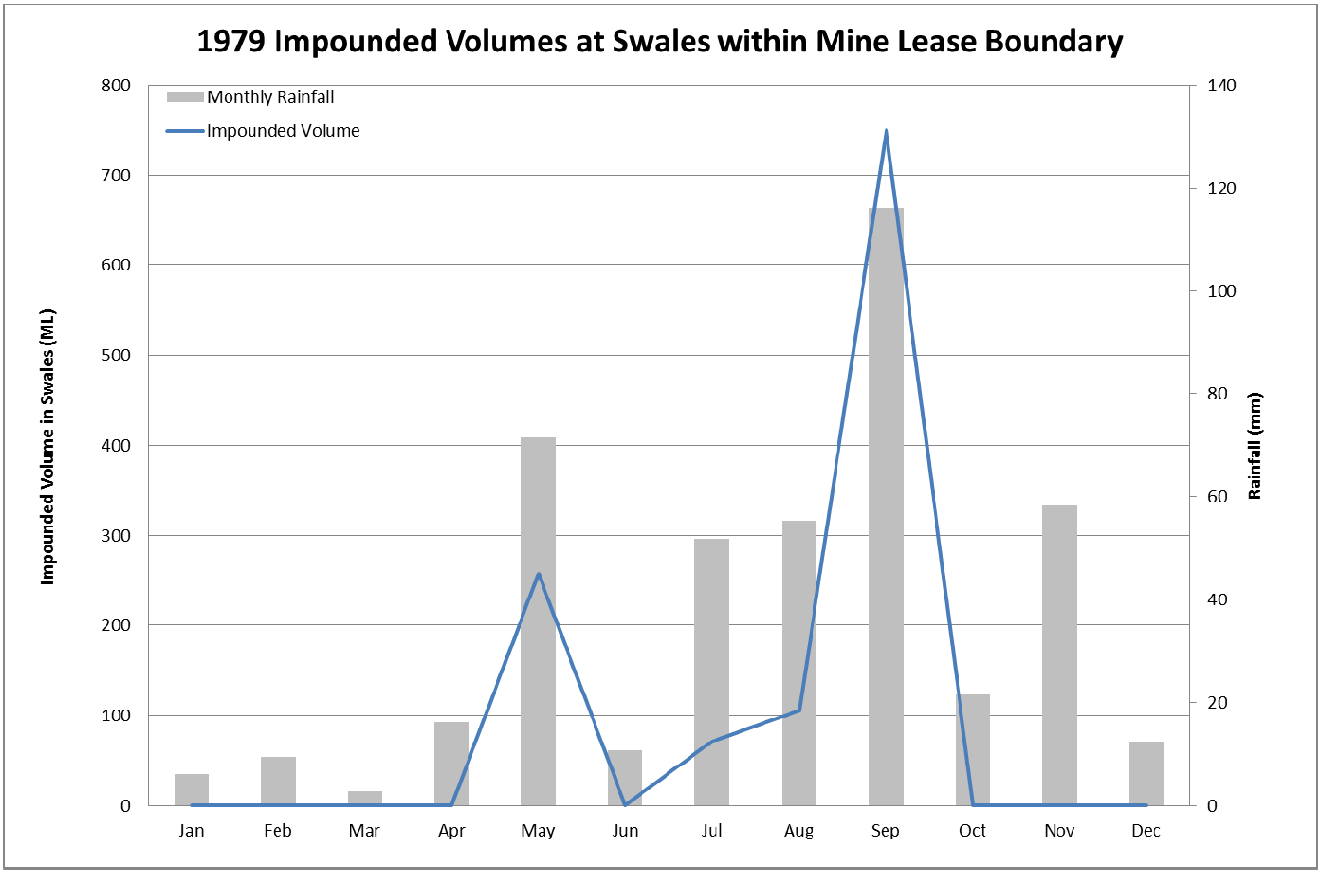


4.4.5 High Winter Rainfall Year - 1979

The high winter rainfall year of 1979 was also among the ten wettest years logged from 1924, with a 432mm total and 115mm in September. The predicted maximum ponded volume is 750 ML in September (Figure 21).

In this case, the lower total annual rainfall of 1979 (430mm) was predicted to result in more than double the ponded volumes of 1992 (rainfall total of 580mm). This is due to the distribution of the rainfall being more consistent in the winter months of 1992 when evapotranspiration is low, and a high spring rainfall, when evapotranspiration is moderate. This produces conditions for higher soil moisture and swale storage.

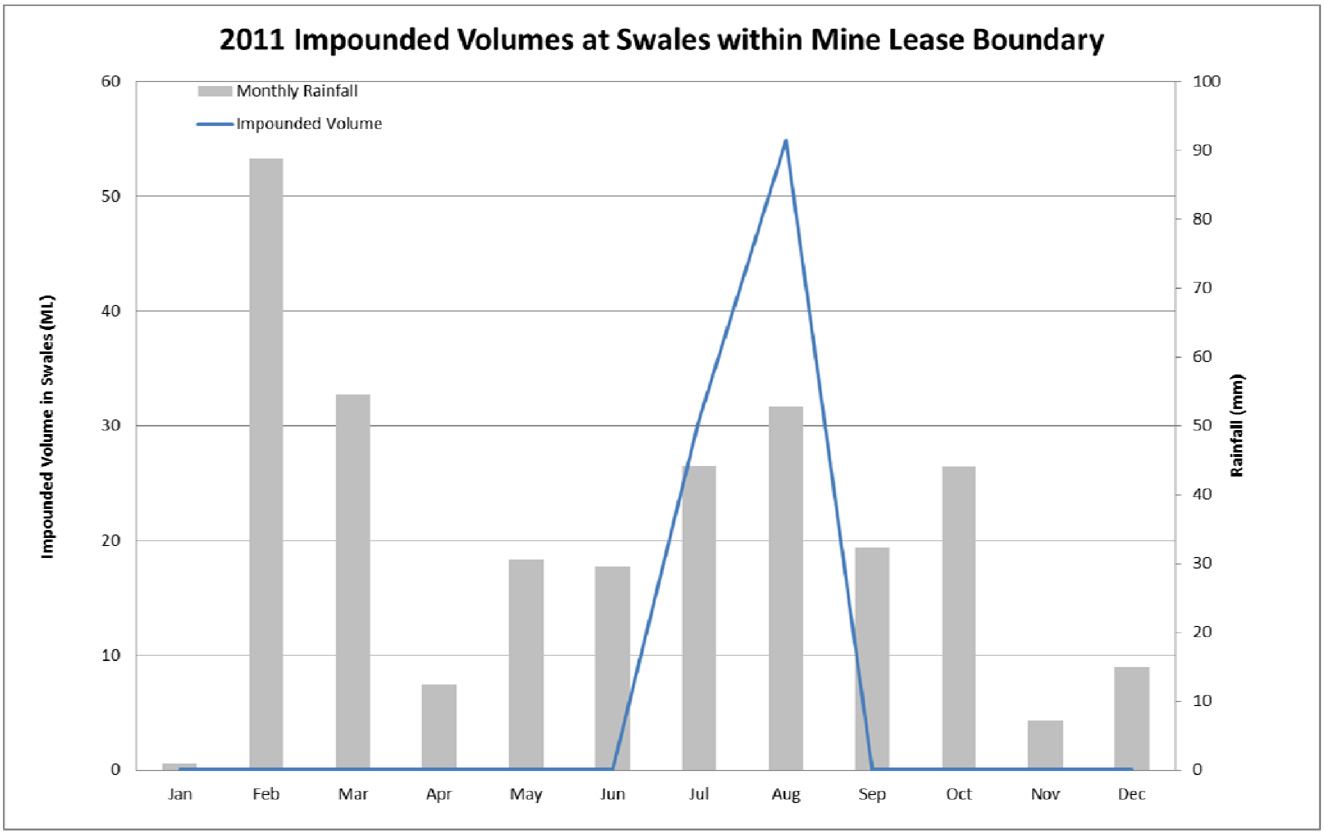
Figure 21: 1979 Ponded Volumes at Swales within the Mine Lease Boundary



4.4.6 High Summer Rainfall Year - 2011

More recently, in 2011, high rainfall also occurred in the project site, making it the 12th wettest year since 1924. The total annual rainfall was 412mm (compared to the average of 325mm), and with 89mm falling in February and 53mm in August. The predicted ponded volume for 2011 is low, however, only reaching 55ML in August (Figure 22), which is similar to an average year (see Figure 17). This is due mainly to most of the rainfall occurring in the summer months of 2011, in particular the high rainfall in February and March, although the high summer rainfall is predicted to not produce any ponding. These predictions are consistent with recollections by landholders during the site visit in May 2013.

Figure 22: 2011 Ponded Volumes at Swales within the Mine Lease Boundary



4.4.7 Summary of CEWB Model Results (Pre-Mining) for CH2

Table 11 summarises the CEWB model results for the calibration year of 2013, and its application to data from a range of relatively wet years with wide variations in rainfall distributions.

Table 11: CEWB model results for pre-mining conditions

Year	Rainfall input to CEWB model	Annual rainfall (mm)	Max. Predicted Swale ponded volume (ML)	Month of maximum ponding
-	Average Year	325	55	August
1957	Lowest annual rainfall total	171	12	July
1968	Highest annual rainfall total; very wet winter	581	1,522	August
1992	2nd highest annual rainfall total; wet spring & summer	580	333	September
1979	High winter rainfall	432	749	September
2011	High summer rainfall	412	55	August
2013	Calibration data to July	237 (to July)	288	(July)

4.5 Application of CEWB model to CH1 (pre-mining)

Land form contours in CH1 indicate that if any surface water is generated in CH1 that it will likely collect in swales that are intersected by the southern Mine Lease boundary. As shown in Figure 23, there are five small sub-catchments along the IWL boundary that, in the pre-development condition, may potentially report drainage flows to low areas to the boundary of the mining lease. Sub-catchments IC-1 to IC-4 have the potential to generate flow towards the IWL boundary and IC-5 is likely to drain towards the middle of the site.

Runoff from these sub-catchments will not be required to be contained at the commencement of mining activity as the primary activity affecting this part of the mine site impact is the construction of the IWL. Given that the IWL will progressively cover these sub-catchment areas as mining progresses, there will be a requirement to manage any drainage that arises from this disturbed catchments until such time as the IWL is completed.

As the IWL is gradually expanded some minor earthworks (earthen bund construction) in swales that intersect the mine lease boundary will be adequate to contain any surface water generated in the sub-catchments with disturbance.

The sub-catchment areas as are as follows:

- IC-1: 316 ha
- IC-2: 226 ha
- IC-3: 252 ha
- IC-4: 290 ha
- IC-5: 62.3ha

The CEWB model predicted drainage volumes reporting to the low lying areas in these sub-catchments, as shown in Figure 23, during mining are summarised in Table 12.

Table 12: IWL drainage water balance results

Year	Rainfall input to CEWB model	Annual rainfall (mm)	Volume of drainage reporting to low areas in each sub-catchment(ML)					Total Reporting to Low Areas (ML)	Month peak reached
			IC-1	IC-2	IC-3	IC-4	IC-5		
-	Average Year	325	2.7	2.0	2.2	2.5	0.5	10.0	August
1957	Lowest annual rainfall total	171	0.5	0.4	0.4	0.5	0.1	1.9	July
1968	Highest annual rainfall total; very wet winter	581	68.0	48.8	54.3	62.5	13.4	247.1	August
1992	2nd highest annual rainfall total; wet spring & summer	580	14.7	10.6	11.8	13.5	2.9	53.5	September
1979	High winter rainfall	432	33.4	24.0	26.7	30.7	6.6	121.3	September
2011	High summer rainfall	412	2.4	1.7	1.9	2.2	0.5	8.7	August
2013	Calibration data to July	237 (to July)	12.7	9.1	10.1	11.7	2.5	46.2	(July)

These sub-surface drainage volumes reporting to the low areas will pond temporarily and will dissipate via evaporation within a short period of time. Analysis of the ponding patterns for each of the scenarios in Table 12 suggests that even in the wettest winters, ponded water only persists until around October, a maximum of only one or two months beyond the timing of the peak pond volume.

4.6 Conclusions on pre-mining surface water assessment

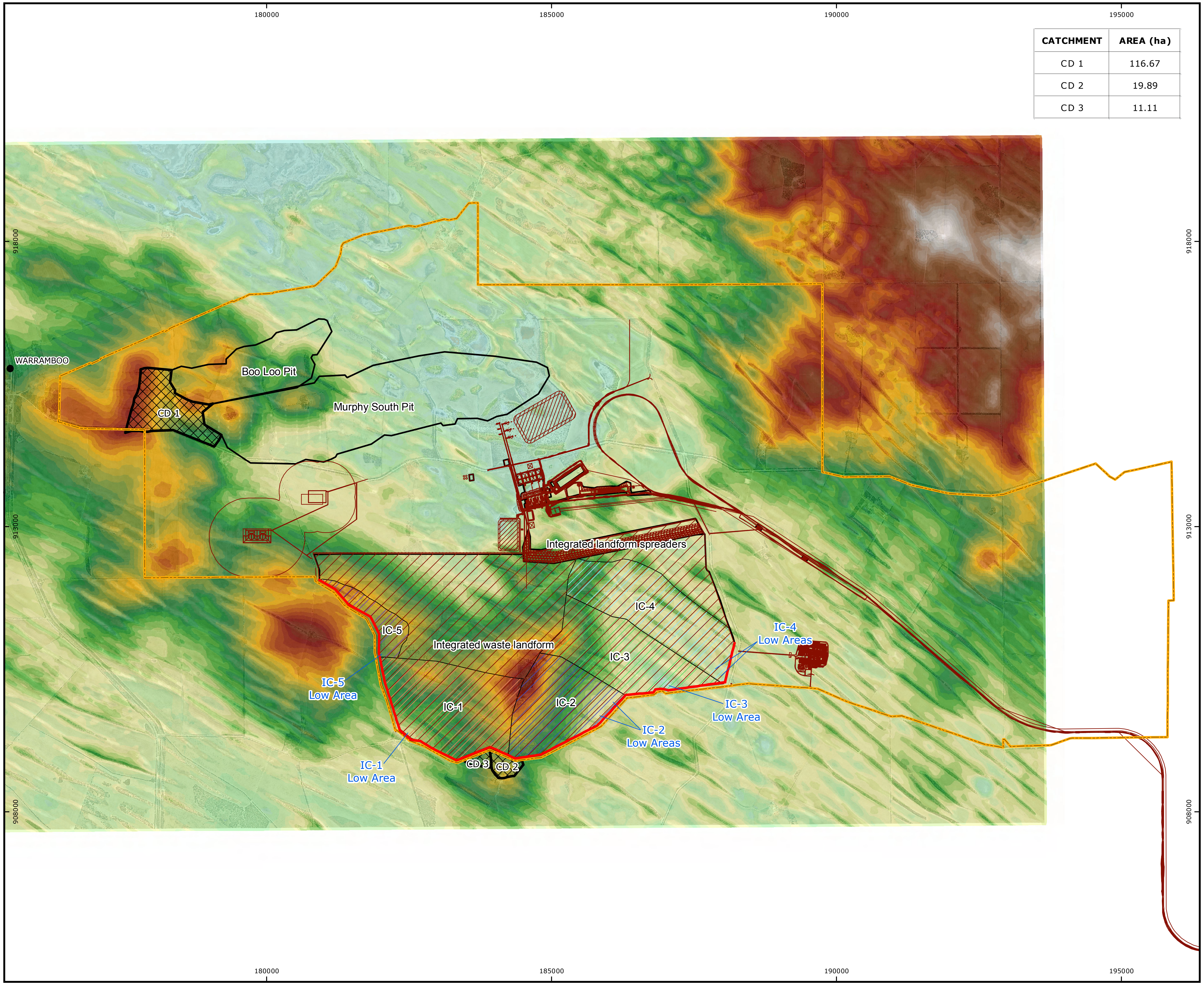
For the CEIP project, the application of the more pragmatic developed CEWB model method to estimate drainage volumes is considered valid, given:

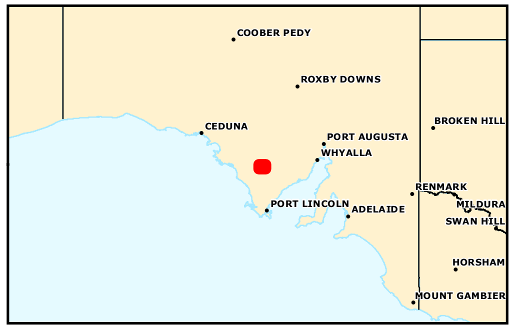
- The permeability of the surface materials,
- The relatively low rainfall intensities,
- The generally deep water table levels (except in low lying and swale areas) and consequent high sub-surface storage volumes, and
- The lack of evidence of surface runoff (no creek or drainage network apart from low lying areas and swales).

The CEWB model calibration and historical monthly rainfall simulation results confirm that the main drainage risk is that of partial filling of swales under conditions of high winter rainfall (when evapotranspiration is lowest), with the maximum ponded volumes typically in August or September. Summer rainfall is a low risk for significant ponding, which is consistent with the anecdotal views of local landholders.

The calibrated CEWB model has been used to predict ponded volumes in swales and low lying areas within the mine lease boundary during mining and post mining activities, and compared with the natural conditions (see sections 5.1 and 5.2).

CATCHMENT	AREA (ha)
CD 1	116.67
CD 2	19.89
CD 3	11.11





LEGEND

- Earthen Bund/IWL Batter
- October Updated Mine 2014108
- Drainage Catchment
- New Mine Areas
- Proposed Mine Lease Boundary

Internal Catchment Boundaries

- IC1- 315.5ha
- IC2- 226.4ha
- IC3- 251.9ha
- IC4- 289.9ha
- IC5- 62.3ha

Elevation (mAHD)

60 - 62	90 - 92	120 - 122
62- 64	92 - 94	122 - 124
64 - 66	94 - 96	124 - 126
66 - 68	96 - 98	126- 128
68 - 70	98 - 100	128 - 130
70 - 72	100 - 102	130 - 132
72 - 74	102 - 104	132 - 134
74 - 76	104 - 106	134 - 136
76 - 78	106 - 108	136 - 138
78 - 80	108 - 110	138 - 140
80 - 82	110- 112	140 - 142
82 - 84	112 - 114	142 - 144
84 - 86	114 - 116	144 - 146
86 - 88	116- 118	146 - 148
88 - 90	118 - 120	148 - 150

N

1,000 0 1,000 2,000

Metres

APPROX SCALE 1:65,000 @ A3

GDA 1994 MGA Zone 54

RPS

FIGURE 23

Drainage Affected By Mining Facilities

RPS

5 Mining and Post-Mining Drainage

5.1 Drainage to Swales and low lying areas under mining conditions

The calibrated CEWB model (see section 4.3) has been applied to the affected areas within the Mine Lease along with the historical rainfall data detailed in section 4.4, to assess the surface water volumes expected to be collected in residual low lying areas adjacent to the pit and IWL.

The following areas have been calculated from the contributing catchment CH2, assuming the excavation of the pit occurs gradually according to the mining plan:

• Mined pit area:	Year 1:	222 ha
	Year 2:	364 ha
	Year 5:	611 ha
	Year 8:	681 ha
	Year 15:	859 ha
	Year 18 to 21:	896 ha
• Fully developed IWL:		717 ha
• Fully developed process facilities area (within CH2):		188 ha

For the development of the mining pit some of the swales will be excavated, namely:

- S11, S12, S13 and S14 from development year Y1, accounting for 31% of the available storage swale volume, and
- S17, S18 and 15% of S20 from development year Y5, accounting for an additional 8% of the available swale storage volume.

The sub-surface drainage that would naturally report to the former swales will be intercepted by the open pits and will not report to any surface storage.

It is noted that the development of the process facilities area will interfere with the surface storage in swale S20. Whilst this will reduce the available storage volume in S20 from development year Y1, it does not impact on the sub-surface drainage processes or the amount of water reporting to S20. However, it may mean that active management of surface water in S20 is required in wet winters to ensure that its capacity is not exceeded, which may otherwise overtop into the pit or processing facility area.

The CEWB model predicts volumes of drainage during mining from catchment CH2 that could potentially report to the swales and low lying areas. The mining facilities (open pits, IWL and facilities area) have been excluded from the contributing catchments. The sub-surface drainage not reporting to swales has also been deducted (i.e. 31% and 39% of the predicted available sub-surface drainage from development year Y1 and Y5 respectively). The calculated ponded volumes in swales amounts to a reduction of about 50% of ponded volumes reporting to the swales compared to the pre-mining situation (see Table 13). However, the occurrence of a wet year (e.g. like 1968) with large rainfall events occurring between May and September could result in large accumulated volumes in the swales, with the maximum predicted being 1,000ML (Table 13). This volume will tend to pond in the remaining swales and the low lying areas around the east of Murphy Pit. Details of the engineering solutions and recommendations related to these ponding volumes can be found in section 6.1.

Deducting the storage volume of the swales excavated by the pit, and the reduction in swale S20 volume due to processing facility area, the maximum remaining storage capacity in swales will be 819 ML from Y1 to Y5 and 720 ML from Y5 onwards. The calculated ponded volumes during mining for a 1968 rainfall year (highest recorded) are 1,000 ML prior Y5 and 833 ML for Y5 onwards (Table 13).Therefore the 1968 rainfall is calculated to have filled the available pre-mining swale storage to about 80% of full capacity (1,000 ML / 1,277 ML), and the swale storage available during mining would be exceeded beyond full capacity (1,000 ML / 819 ML (Y1 to Y5; 1,000 ML / 720 ML Y5 onwards). Therefore it will be important in a particularly wet year that the swales adjacent to the pit or processing facilities are actively drained during the winter period to reduce the risk of damage to infrastructure (see section 6.1).

It is difficult to establish the probability of occurrence of a very wet year such as 1968, as there must be consideration of hydrological effects, not simply rainfall analysis. The 1968 annual rainfall (581mm) was almost the same as for 1992 (580mm). Considering the period of record of 90 years of rainfall data, a very simple analysis would suggest a probability of occurrence in the order of 2% in any one year (or an ARI of around 50 years). However, the distribution of rainfall is quite different, with 1992 having a very wet spring and summer, whereas 1968 had relatively high rainfall for each month of the year, and very high rainfall in winter. The hydrological result is that a year like 1968 would result in substantial pondage of water in swale areas (due to wet antecedent conditions and a wet winter when there is low evaporation). However, when high rainfall occurs outside winter months (when there is high evaporation) during an otherwise wet year like 1992, the hydrological effects are substantially reduced (see Table 11). Hence it could be argued that a wet year such as 1968 has a probability of occurrence of around 1% in any one year (or an ARI in the order of 100 years), which would translate to a probability of occurrence of 18% in the 20 year mine life (see section 5.3.2).

The CEWB model demonstrates that the swale filling and draining process will continue during mining and post-mining, consistent with current conditions whereby the swale storages are known to evaporate and drain during the spring period.

Table 13: CEWB model results for estimated drainage volumes to swales and low lying areas under mining conditions

CEWB model drainage volume (ML) to swales in catchment CH2 under mining conditions					
Mine Year	Simulation	Annual rainfall (mm)	Max. volume available (ML)	Reporting to Swales (ML)	Month
Year 1	Average Year	325	58.5	40.4	Aug
	Year 1957 (Lowest annual rainfall total)	171	10.9	7.5	Jul
	Year 1968 (Highest annual rainfall total; very wet winter)	581	1449.9	1000.4	Aug
	Year 1992 (2nd highest annual rainfall total; wet spring & summer)	580	313.4	216.3	Sep
	Year 1979 (High winter rainfall)	432	711.8	491.1	Sep
	Year 2011 (High summer rainfall)	412	51.3	35.4	Aug
	Year 2013+	237 (to July)	270.9	186.9	Jul
Year 2	Average Year	325	57.3	39.5	Aug
	Year 1957 (Lowest annual rainfall total)	171	10.7	7.3	Jul
	Year 1968 (Highest annual rainfall total; very wet winter)	581	1419.3	979.3	Aug
	Year 1992 (2nd highest annual rainfall total; wet spring & summer)	580	307.1	211.9	Sep
	Year 1979 (High winter rainfall)	432	696.7	480.7	Sep
	Year 2011 (High summer rainfall)	412	50.2	34.6	Aug
	Year 2013+	237 (to July)	265.1	182.9	Jul
Year 5	Average Year	325	55.2	33.6	Aug
	Year 1957 (Lowest annual rainfall total)	171	10.3	6.3	Jul
	Year 1968 (Highest annual rainfall total; very wet winter)	581	1366.0	833.3	Aug
	Year 1992 (2nd highest annual rainfall total; wet spring & summer)	580	295.6	180.3	Sep
	Year 1979 (High winter rainfall)	432	670.6	409.0	Sep
	Year 2011 (High summer rainfall)	412	48.3	29.5	Aug
	Year 2013+	237 (to July)	255.2	155.7	Jul
Year 8	Average Year	325	54.5	33.3	Aug
	Year 1957 (Lowest annual rainfall total)	171	10.1	6.2	Jul
	Year 1968 (Highest annual rainfall total; very wet winter)	581	1350.9	824.1	Aug
	Year 1992 (2nd highest annual rainfall total; wet spring & summer)	580	292.3	178.3	Sep
	Year 1979 (High winter rainfall)	432	663.2	404.5	Sep
	Year 2011 (High summer rainfall)	412	47.8	29.1	Aug
	Year 2013+	237 (to July)	252.4	153.9	Jul
Year 15	Average Year	325	53.0	32.3	Aug
	Year 1957 (Lowest annual rainfall total)	171	9.9	6.0	Jul
	Year 1968 (Highest annual rainfall total; very wet winter)	581	1312.5	800.6	Aug
	Year 1992 (2nd highest annual rainfall total; wet spring & summer)	580	284.0	173.2	Sep
	Year 1979 (High winter rainfall)	432	644.3	393.0	Sep
	Year 2011 (High summer rainfall)	412	46.4	28.3	Aug
	Year 2013+	237 (to July)	245.2	149.6	Jul
Year 18 - Year 21	Average Year	325	52.7	32.1	Aug
	Year 1957 (Lowest annual rainfall total)	171	9.8	6.0	Jul
	Year 1968 (Highest annual rainfall total; very wet winter)	581	1304.5	795.8	Aug
	Year 1992 (2nd highest annual rainfall total; wet spring & summer)	580	282.3	172.2	Sep
	Year 1979 (High winter rainfall)	432	640.4	390.6	Sep
	Year 2011 (High summer rainfall)	412	46.1	28.1	Aug
	Year 2013 (to July)	237 (to July)	243.7	148.7	Jul

5.2 Drainage to swales and low lying areas under post-mining conditions

After the mine closure, the pit and the IWL will continue to be drained internally, but the process facilities will be dismantled and that area will be rehabilitated, resulting in drainage back to the low lying areas and swales.

For the post-mining case, the following areas have been deducted from the contributing catchment CH2 as they are addressed as stand-alone assessments:

- Fully-mined pits: 896 ha.
- Fully developed IWL: 717 ha.

The CEWB model predicted drainage volumes reporting to the remaining swales and low lying areas in catchment CH2 post-mining are summarised in Table 14.

Table 14: Post-Mining Water balance results

Year	Rainfall input to CEWB model	Annual rainfall (mm)	Max. Volume available (ML)	Reporting to Swales (ML)	Month
-	Average Year	325	54.3	33.1	August
1957	Lowest annual rainfall total	171	10.1	6.2	July
1968	Highest annual rainfall total; very wet winter	581	1345.1	820.5	August
1992	2nd highest annual rainfall total; wet spring & summer	580	291.0	177.5	September
1979	High winter rainfall	432	660.3	402.8	September
2011	High summer rainfall	412	47.6	29.0	August
2013	Calibration data to July	237 (to July)	251.3	153.3	(July)

Overall the changed contributing areas means a reduction of about 45% of ponded volumes reporting to the swales compared to the pre-mining situation.

These volumes will tend to pond in the remaining swales and low lying areas, in some cases partially draining directly into the excavated open pits (e.g. swales 19 and 20).

5.3 In-Pit Rainfall-Runoff

The pits are self-contained drainage catchments collecting the runoff from direct rainfall within the limits of the pits. Pit development will occur progressively along the mine life, and the estimation of runoff volumes needs to take account of the pit area at specific stages. Runoff estimates are required to size dewatering infrastructure and hence minimise the risks to timely mine development and operation. The runoff volume is calculated as the product of rainfall, catchment area and volumetric runoff coefficient (VRC).

RPS has access to unpublished data on Volumetric Runoff Coefficients (VRCs) applicable to operating open cut mines within the Pilbara region (Western Australia), based on measurements from a wide range of major rainfall events over the last few decades. Also RPS has recently completed (unpublished) hydrological studies for the in-pit drainage of the future extension of the Olympic Dam open cut mine, and this has been benchmarked against the Pilbara information. Based on the climatological and geological similarities of both regions with the Central Eyre region we have used this information to extrapolate volumetric runoff volumetric coefficients for different ARIs. The adopted VRC for the pit catchments are summarised below:

- VRC = 0.33 for a 2 year ARI or less (virtually 100% probability of occurrence within 20 year mine life)
- VRC = 0.40 for a 10 year ARI (88% probability of occurrence within 20 year mine life)
- VRC = 0.45 for the 20 year ARI (64% probability of occurrence within 20 year mine life)
- VRC = 0.54 for the 50 year ARI (33% probability of occurrence within 20 year mine life)

- VRC = 0.61 for the 100 year ARI (18% probability of occurrence within 20 year mine life).

5.3.1 Monthly in-pit surface water volumes

For the purpose of estimating the monthly surface water volumes that are expected to be collected by the pits (i.e. for input to the site water balance model), we have selected a VRC of 0.33, corresponding to higher frequency (or small return period) events (2 year ARI or less), and applied the effective monthly rainfall, which is the recorded monthly rainfall less initial loss. The initial loss helps account for the typically dry and well-drained antecedent conditions expected due to the influence of mine dewatering. Typical initial loss values of the SA natural catchments are very variable, namely from 10mm in winter to 25mm in summer, depending greatly on the type of soil and general slope of the catchment (ARR Book 2, Engineers Australia 2001). The recommended initial loss values for rocky-steep catchments (>3% general slope) can vary from 0.5mm to 7mm per rainy event depending on the wet conditions of the rock (US Soil Conservation Service Hydrology, 1986). We have adopted a value of 15mm per month, considering an average of 3 rainy events per month at 5mm per event. We have selected three rainfall scenarios to evaluate:

- A typically dry year (1957, driest recorded year, with less than 200 mm of annual rainfall),
- An average year (statistically generated), and
- A very wet year with high winter rainfall (1968 has the highest total rainfall in the 90 year record, which is equivalent a 1% probability of occurrence in any given year).

The monthly results are summarised in Table 15. The water volumes are calculated before any evaporation takes place, since these volumes will be pumped out of the pit in a continuous basis and not left to pond within the pits.

The values in Table 15 can be used as input for an overall mine site water balance model (like SysCAD) for the simulation of average, particularly wet and particularly dry years.

Table 15: Average Monthly in-pit surface water volumes (ML) for use in site water balance assessments

Contributing Catchment			Murphy Y1	Murphy Y2	Murphy Y5	Murphy Y8	Murphy Y15	Boo Loo Y15	Murphy Y18 / Y21	Boo Loo Y18 / Y21
Pit Foot Print Area (ha)			222.2	364.2	611.4	681.4	680.0	178.8	680.0	215.8
Bottom Pit EL (m AHD)			39	-9	-141	-309	-405	68	-465/-537	-52/-220
Rainfall	**Recorded (mm)**	**Effective (mm)**	**1957 (dry year) in-pit monthly surface water volumes (ML), VRC= 0.33**							
January	1	0	0	0	0	0	0	0	0	0
February	1	0	0	0	0	0	0	0	0	0
March	6	0	0	0	0	0	0	0	0	0
April	3	0	0	0	0	0	0	0	0	0
May	13	0	0	0	0	0	0	0	0	0
June	33	18	13	21	36	40	40	10	40	13
July	38	23	17	28	47	53	53	14	53	17
August	28	13	9	15	26	29	29	8	29	9
September	11	0	0	0	0	0	0	0	0	0
October	7	0	0	0	0	0	0	0	0	0
November	10	0	0	0	0	0	0	0	0	0
December	21	6	5	7	13	14	14	4	14	4
Annual	**171**	**60**	**44**	**72**	**122**	**136**	**135**	**36**	**135**	**43**
Rainfall	**Recorded (mm)**	**Effective (mm)**	**Average year in-pit monthly surface water volumes (ML), VRC= 0.33**							
January	13	0	0	0	0	0	0	0	0	0
February	16	1	1	1	2	2	2	1	2	1
March	14	0	0	0	0	0	0	0	0	0
April	20	5	4	6	10	11	11	3	11	4
May	34	19	14	23	39	43	43	11	43	14
June	43	28	20	33	56	62	62	16	62	20
July	45	30	22	36	61	68	68	18	68	21
August	43	28	21	34	57	63	63	17	63	20
September	34	19	14	22	38	42	42	11	42	13
October	26	11	8	13	23	25	25	7	25	8
November	20	5	4	6	10	11	11	3	11	3
December	20	5	4	6	10	11	11	3	11	4
Annual	**328**	**151**	**111**	**182**	**305**	**340**	**339**	**89**	**339**	**108**
Rainfall	**Recorded (mm)**	**Effective (mm)**	**1968 (wet year) in-pit monthly surface water volumes (ML), VRC= 0.33**							
January	30	15	11	17	29	33	33	9	33	10
February	42	27	20	33	55	61	61	16	61	19
March	60	45	33	54	90	100	100	26	100	32
April	36	21	15	25	42	47	47	12	47	15
May	60	45	33	54	90	101	100	26	100	32
June	110	95	70	115	192	214	214	56	214	68
July	82	67	49	80	135	150	150	39	150	48
August	57	42	31	51	86	95	95	25	95	30
September	27	12	9	15	25	28	27	7	27	9
October	30	15	11	18	29	33	33	9	33	10
November	23	8	6	10	16	18	18	5	18	6
December	25	10	7	12	20	22	22	6	22	7
Annual	**581**	**401**	**294**	**482**	**810**	**902**	**901**	**237**	**901**	**286**

5.3.2 Major Rainfall Events and Probability of Occurrence

Estimates of in-pit surface water runoff volumes have been calculated using the VRC methodology described in the previous section and applying the rainfall intensity as calculated from the IFD curves (section 3.5.3) for a 72 hour storm duration event (i.e. maximum volume event) at ARIs of 2, 10, 20, 50 and 100 years.

It is common to undertake a major rainfall event flow analysis for the 72 hour duration event (as this generates the maximum volume) and a range of Average Recurrence Intervals or ARIs up to 100 years, to provide data for the subsequent design of hydraulic structures such as dewatering pumps, diversion channels and culverts. This analysis typically uses methods outlined in Australian Rainfall and Runoff (ARR; Engineers Australia 2001), typically the Rational method. However, in this case, we note that ARR identifies this region as being one where there is no recommended method for rainfall-runoff estimation, neither for natural catchments, nor for disturbed and mined areas. For the CEIP project, a pragmatic method is applied for the estimation of drainage volumes using benchmarked volumetric runoff coefficients, and with consideration of rainfall IFD information to provide guidance on the probability of occurrence (or “risk”).

When predicting maximum volumes for a given return period no initial rainfall losses should be considered. This is because, in a worst case scenario, wet antecedent conditions should be assumed, as a major rainfall event could occur just after minor rainfall or in the middle of a wet period, when the rock is saturated and rock infiltration is virtually nonexistent. In other words, for major events, an initial loss approach is not suitable (unlike the average monthly volume method outlined in 5.3.1).

Table 16 summarises the results of the major rainfall event runoff volume calculations for the pit.

Table 16: In-pit runoff volumes for 72 hour duration event

Contributing Catchment	Murphy Y1	Murphy Y2	Murphy Y5	Murphy Y8	Murphy Y15	Boo Loo Y15	Murphy Y18/ Y21	Boo Loo Y18/ Y21
Area (ha)	222.2	364.2	611.4	681.4	680.0	178.8	680.0	215.8
Runoff Volume (ML) for ARI 100 years, VRC = 0.61 and 72 hour rainfall of 131 mm								
Volume (ML)	177.6	291.0	488.6	544.5	543.4	142.9	543.4	172.4
Runoff Volume (ML) for ARI 50 years, VRC = 0.54 and 72 hour rainfall of 112 mm								
Volume (ML)	134.4	220.3	369.8	412.1	411.3	108.1	411.3	130.5
Runoff Volume (ML) for ARI 20 years, VRC = 0.45 and 72 hour rainfall of 89 mm								
Volume (ML)	89.0	145.9	244.9	272.9	272.3	71.6	272.3	86.4
Runoff Volume (ML) for ARI 10 years, VRC = 0.40 and 72 hour rainfall of 74 mm								
Volume (ML)	54.3	88.9	149.3	166.4	166.1	43.7	166.1	52.7
Runoff Volume (ML) for ARI 2 years, VRC = 0.33 and 72 hour rainfall of 47 mm								
Volume (ML)	34.5	56.5	94.8	105.7	105.5	27.7	105.5	33.5

The selection of the design hydraulic capacity for a structure is related to its design life (L) and the probability of the design storm event occurring during the life. In this case, the mine will be operational for a period of 20 years, and a 50 year ARI event has a 33% probability of occurrence during the mine life (Table 17). Another way to consider this is to note that, while a 100 year ARI has a probability of occurrence of 1% in any one year, the probability of occurrence over the 20 year mine life is 18%. It is recommended that a 50 year ARI would be a reasonable design capacity for surface water management infrastructure for the project.

Table 17: Probability of flood occurrence of an ARI (years) event in a period of L years

Design Life	**Design Flood Average Recurrence Interval ARI (years)**												
L (years)	**1**	**2**	**5**	**10**	**20**	**30**	**40**	**50**	**75**	**100**	**200**	**500**	**1000**
1	1.0000	0.5000	0.2000	0.1000	0.0500	0.0333	0.0250	0.0200	0.0133	0.0100	0.0050	0.0020	0.0010
2	1.0000	0.7500	0.3600	0.1900	0.0975	0.0656	0.0494	0.0396	0.0265	0.0199	0.0100	0.0040	0.0020
3	1.0000	0.8750	0.4880	0.2710	0.1426	0.0967	0.0731	0.0588	0.0395	0.0297	0.0149	0.0060	0.0030
4	1.0000	0.9375	0.5904	0.3439	0.1855	0.1268	0.0963	0.0776	0.0523	0.0394	0.0199	0.0080	0.0040
5	1.0000	0.9688	0.6723	0.4095	0.2262	0.1559	0.1189	0.0961	0.0649	0.0490	0.0248	0.0100	0.0050
10	1.0000	0.9990	0.8926	0.6513	0.4013	0.2875	0.2237	0.1829	0.1256	0.0956	0.0489	0.0198	0.0100
15	1.0000	1.0000	0.9648	0.7941	0.5367	0.3986	0.3160	0.2614	0.1824	0.1399	0.0724	0.0296	0.0149
20	1.0000	1.0000	0.9885	0.8784	0.6415	0.4924	0.3973	**0.3324**	0.2354	0.1821	0.0954	0.0392	0.0198
25	1.0000	1.0000	0.9962	0.9282	0.7226	0.5715	0.4690	0.3965	0.2851	0.2222	0.1178	0.0488	0.0247
30	1.0000	1.0000	0.9988	0.9576	0.7854	0.6383	0.5321	0.4545	0.3315	0.2603	0.1396	0.0583	0.0296
35	1.0000	1.0000	0.9996	0.9750	0.8339	0.6947	0.5877	0.5069	0.3749	0.2966	0.1609	0.0677	0.0344
40	1.0000	1.0000	0.9999	0.9852	0.8715	0.7423	0.6368	0.5543	0.4155	0.3310	0.1817	0.0770	0.0392
45	1.0000	1.0000	1.0000	0.9913	0.9006	0.7825	0.6800	0.5971	0.4534	0.3638	0.2019	0.0862	0.0440
50	1.0000	1.0000	1.0000	0.9948	0.9231	0.8164	0.7180	0.6358	0.4889	0.3950	0.2217	0.0953	0.0488
75	1.0000	1.0000	1.0000	0.9996	0.9787	0.9213	0.8503	0.7802	0.6346	0.5294	0.3134	0.1394	0.0723
100	1.0000	1.0000	1.0000	1.0000	0.9941	0.9663	0.9205	0.8674	0.7388	0.6340	0.3942	0.1814	0.0952

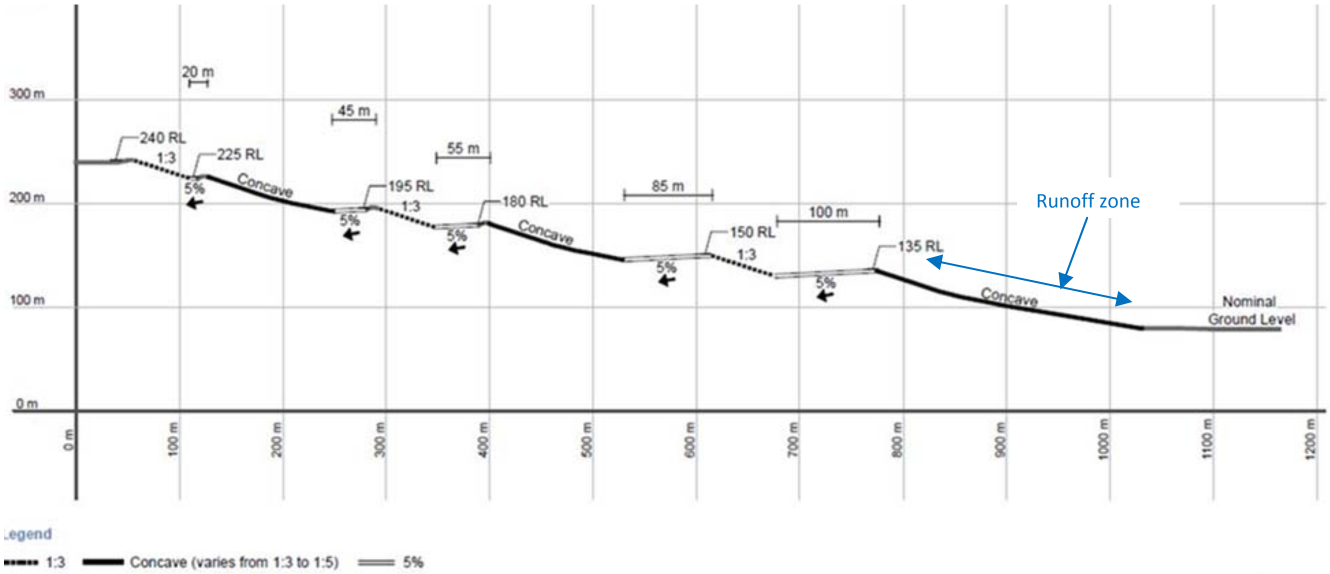
5.4 Sub-Catchment Drainage affected by Mining Facilities

5.4.1 IWL Catchment Area Drainage

Construction of the IWL is designed to minimise potential for runoff in the direction of the southern Mine Lease Boundary. The small catchments within the IWL boundary shown in Figure 23 will be progressively re-formed so as to intercept rainfall runoff within the new waste rock formation. The ponding of sub-catchment drainage volumes will progressively reduce as the IWL is constructed, with the surface of the IWL to be shaped with benches and internal batters such that any rainfall (and potential runoff) will stay on or within the IWL itself. Only the outer batter of the IWL will generate runoff as it will be capped and will drain externally.

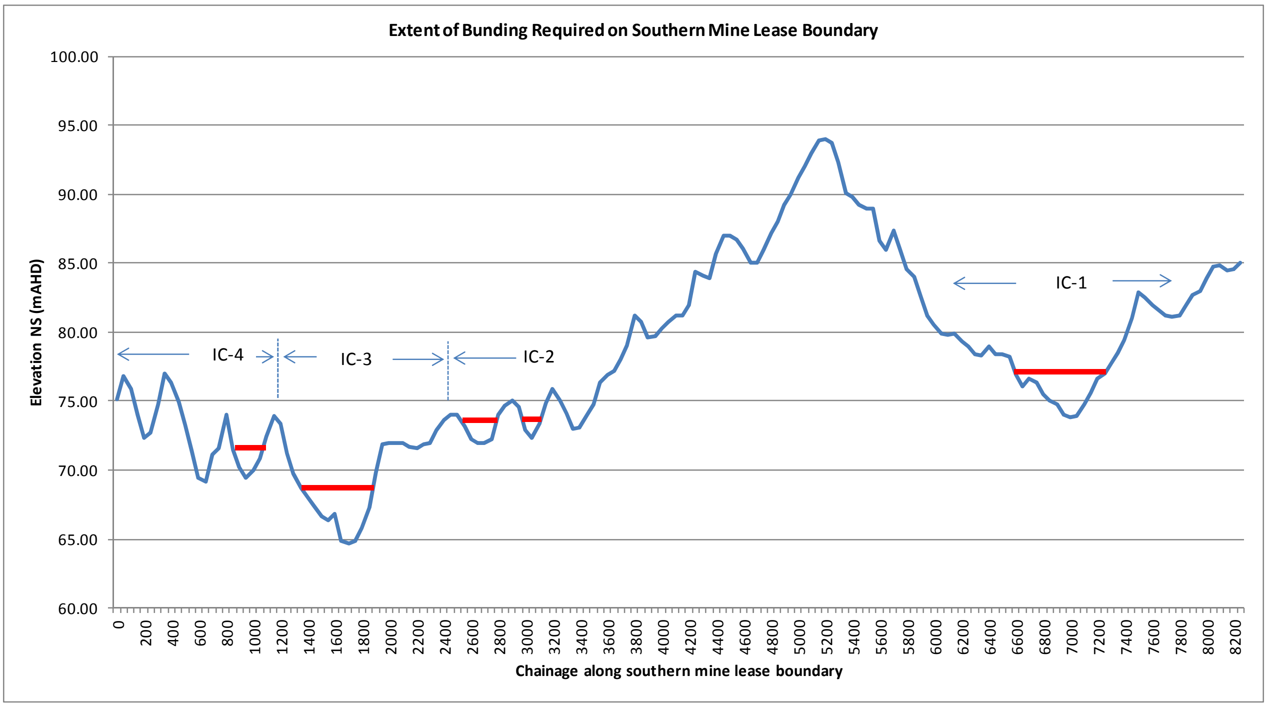
A generalised representation of the IWL elevation section is shown in Figure 24 below and further details of the design of the IWL are included in other approvals documentation.

Figure 24 – Proposed IWL form



Sub-catchment models (described in Table 12) were used to examine the potential impacts for progressive IWL formation across the undisturbed site. The worst-case peak for generating ponded water volume in each sub-catchment is the 1968 rainfall scenario resulting in between 13.4 ML and 68.0 ML. Analysis of the swale geometry and volumes in this area (see Figure 25) indicates that this volume of water can be suitably contained with the construction of a bund of minimum height 3 m, across the low points at approximate chainages 750m, 1,650m, 2,700m, 3,000m and 7,000m as shown below.

Figure 25 – Southern Mine Lease Boundary Long Section and Proposed Bunding Arrangement



The only areas of the IWL that will generate runoff on the mine lease boundary side will be the outside batters which will be covered with a topsoil layer to support revegetation (as shown in Figure 25). Any runoff arising from this outside batter will move toward the mining lease buffer zone and potentially off-lease without intervention. The volume of water running off from this area (approx. 10,300m x ~250m = 257 ha), when the first lift of the IWL is fully developed, has been determined for a dry, average and wet scenario, as shown in Table 18.

Table 18: IWL batter runoff volumes

Month	1957 (dry year) monthly runoff volumes (ML), VRC= 0.33			Average year monthly runoff volumes (ML), VRC= 0.33			1968 (wet year) monthly runoff volumes (ML), VRC= 0.33		
	Recorded rainfall (mm)	Effective rainfall (mm) (15mm initial loss assumed)	Runoff from IWL batter (257 ha)	Recorded rainfall (mm)	Effective rainfall (mm) (15mm initial loss assumed)	Runoff from IWL batter (257 ha)	Recorded rainfall (mm)	Effective rainfall (mm) (15mm initial loss assumed)	Runoff from IWL batter (257 ha)
January	1	0	0	13	0	0	30	15	12
February	1	0	0	16	1	1	42	27	23
March	6	0	0	14	0	0	60	45	38
April	3	0	0	20	5	4	36	21	18
May	13	0	0	34	19	16	60	45	38
June	33	18	15	43	28	24	110	95	81
July	38	23	20	45	30	26	82	67	57
August	28	13	11	43	28	24	57	42	36
September	11	0	0	34	19	16	27	12	10
October	7	0	0	26	11	9	30	15	12
November	10	0	0	20	5	4	23	8	7
December	21	6	5	20	5	4	25	10	8
Annual	**171**	**60**	**51**	**328**	**151**	**128**	**581**	**401**	**341**

These runoff volumes, generally around 20 - 25 ML/month in the average winter months but peaking at 81 ML/month (June 1968), will be contained within a level, dyked batter toe collection sump at the base of the first lift of the IWL. This collection sump will extend the full length of the IWL batter, a length of around 10,300m.

The progressive construction of the IWL means that the storage volume in the sump will need to be available as the project progresses. Intermittent dykes will prevent any movement of water along the sump, with suggested intervals of 1,000m. The runoff retained within the collection sump is assumed to dissipate via evaporation in the same way that swales operate for pre-mining conditions.

A peak estimate of storage volume based on a very wet year with minimal seepage and evaporative losses would require storage capacity of around 17ML/km (adopting 1968; 176 ML cumulative runoff over winter months). To contain this volume the typical collection sump dimensions will need to be in the order of 15m wide and 1.5m deep (1v:2h batters; depth inclusive of 0.2m freeboard) in order to provide enough winter storage for the wet year winter period. It is assumed that this volume will dissipate quickly without ongoing rainfall.

Regular operational decisions will need to be made as the IWL is constructed to manage available storage volumes within the mine lease. It is possible that additional storage could be utilised within the footprint of the IWL if wetter early winter conditions are encountered.

5.4.2 Off-Lease Drainage toward Mining Facilities

During mining all rainfall on the surface area of the open pits, IWL and process facilities is redirected to on-site water storage and treatment and does not contribute to the recharge of the swales or low lying areas. However, there are three sub-catchment areas directly adjacent to the proposed mining facilities draining towards the proposed facilities (Figure 23):

- CD1 on the west side of the pits
- CD2 and CD3 are small areas to the south of the IWL.

There is no indication of high rainfall causing runoff or ponding in these areas based on the findings of the site inspection and hydrological analysis (refer to sections 2, 3 and 4). The local drainage is dominated by infiltration and sub-surface drainage processes (not runoff processes).
Further, it is noted that the locations of these sub-catchments affected by mining facilities maximise the effect of infiltration and minimise the potential for runoff and ponding, as they are located on relatively high ground:

- With high percentages of low and medium permeability dune soils (i.e. away from low-lying and very low permeability areas) with infiltration rates ranging from 10^{-6} to 10^{-4} m/s.
- With an underlying water table around 60-65mAHD, giving a depth to water table in excess of 10 metres in the higher catchments CD1 to CD4, and thus substantial sub-surface storage potential and almost no opportunity for groundwater contributions to ponding in these areas (see Table 19)

Table 19: Sub-catchment areas affected by mining facilities

Contributing Catchment	CD1	CD2	CD3
Contributing area (ha)	116.7	21.5	41.7
Very Low permeability (K= 10^{-8} m/s)	0%	0%	0%
Low Permeability (K= 10^{-6} m/s)	100%	0%	0%
Medium Permeability (K= 1.2×10^{-4} m/s)	0%	100%	100%

Max Elevation (m AHD)	108	98	86
Min Elevation (m AHD)	86.5	90	81.5

Based on the hydrological understanding outlined in Sections 2, 3 and 4, natural drainage in CD1 to CD3 is expected to infiltrate directly to the water table, which lies at more than 10 metres below the surface in these areas. A portion of the infiltrated volumes may generate sub-surface drainage towards the low lying areas and swales, but there is no expectation of surface runoff or surface ponding, other than nuisance-scale effects.

However it is suggested that the foundation embankments for any mining facilities in any inter-dune low areas within these sub-catchments should include surface erosion protection with suitable materials, in the event of any temporary surface ponding against them (see section 6.2 for details on water management techniques and recommendations).

6 Surface Water Management

6.1 Ex-pit Swales and Low Lying areas drainage

As discussed in sections 5.1 and 5.2, swales and low lying areas within the mine lease boundary are expected to collect and maintain seasonal water volumes. Some of the existing swales will be affected (partially or totally) by the mining activities. Of the remaining swales, there are five swales close to and around the eastern end of the Murphy South pit, namely S9, S10, S16, S19 and S20 (see Figure 26).

The proposed management of the water collected in swales is to ensure that it is retained and allowed to either evaporate or seep into the ground. The risk of this is increased infiltration into the pit and possible surface flows over the edge of the pits. Such conditions could potentially occur in exceptionally wet years (noted in section 5.1, a rainfall year similar to 1968 will potentially fill or exceed the capacity of the swales).

Discussions with Iron Road representatives indicated that seepage to the pit has potential to destabilize pit walls and that the preferred option for managing this water is to ensure is moved away from the pit perimeter. To calculate a design volume for storage of drainage water in these swales a 50 year return period was adopted using monthly increments of ponded volume expected during the mining operations. This has been calculated running the CEWB model with the monthly rainfall of 1992 (which is the second wettest year recorded, assessed to have a 50 year return period). Mine developing year Y1 has been identified as the worst case scenario since, due to mining activities, the contributing catchment CH2 has not been fully disturbed and most of the sub-surface drainage still reports to the swales. The calculated volume to be managed is 62.2 ML (see Table 20), which is the simulated volume increment between July and August 1992 rainfall during the mining operations scenario that is expected to pond in swales S9, S10, S16, S19 and S20. The distribution of the total predicted monthly increment volume among the swales S9, S10, S16, S19 and S20 can be inferred using the proportions of the individual swale measured volumes to the total swale measured volume (See Table 10), which is being calculated to be 39.4% (as detailed in Table 21).

Table 20: Calculated ponded volumes during mining operation (Y1) for 1992 rainfall

Month	Cumulative Calculated Ponded Volumes on swales (ML)	Monthly volume increment in catchment CH2 (ML)	Volume to be managed in swales S9, S10, S16, S19 and S20 (ML)
January	0.0	-	
February	0.0	-	
March	0.0	-	
April	1.5	1.5 – 0 = 1.5	39.4% 1.5 = 0.6
May	87.8	87.8 – 1.5 = 86.3	39.4% 86.3 = 34.0
June	0.0	-	
July	0.0	-	
August	157.8	**157.8 – 0 = 157.8**	**39.4% 157.8= 62.2**
September	313.4	313.4 – 157.8 = 155.6	39.4% 155.6 = 61.3
October	0.0	-	
November	0.0	-	
December	0.0	-	

The design flow has been determined in order to drain the maximum expected monthly increment in 10 days. Results are summarised in the following Table 21:

Table 21: Swales S9, S10, S16, S19 and S20 calculated ponded volumes and pump configuration during mining operations

Swale	Percentage of total ponded volume (ML)	Monthly maximum volume increase (ML)	Dewatering Design Flow (l/s)	Pumping head† (m)	Pump Capacity (kW)
S9	117ML/1277ML = 9.2%	157.8ML x 9.2% = 14.5 ML	16.8 l/s	30 m	9.3 kW
S10	64ML/1277ML = 5.0%	157.8ML x 5.0% = 7.9 ML	9.1 l/s	30 m	4.2 kW
S16	202ML/1277ML = 15.8%	157.8ML x 15.8% = 24.9 ML	28.8 l/s	30 m	13.1 kW
S19	3ML/1277ML = 0.2%	157.8ML x 0.2% = 0.3 ML	0.4 l/s	22 m	0.2 kW
S20	118ML/1277ML = 9.2%	157.8ML x 9.2% = 14.5 ML	16.8 l/s	32 m	10.5 kW
Total	**504/1277 ML = 39.4 %**	**157.8 x 39.4 % = 62.2 ML**	**71.9 l/s**	-	**37.4 kW**

† including hydraulic headloss (individual pump lines + main dewatering pipeline to Mine Process Pond)

To facilitate the drainage of the swales and avoid increasing seepage into the pits, it is recommended that trench drains be installed in each swale directing flows away from infrastructure and the pit edge (where possible) and towards a sump collecting flows to be pumped out.

The recommended dimensions for the trench drains is 0.5 m wide by 0.5m deep for main (longitudinal) drains and 0.3 m deep for secondary (transversal) drains. The recommended drains are open trench with battered sides (1H:1V) and a minimum slope of 0.15% for main and secondary drains to meet the required capacity. The dimensions of the drain trenches can be seen in Table 22.

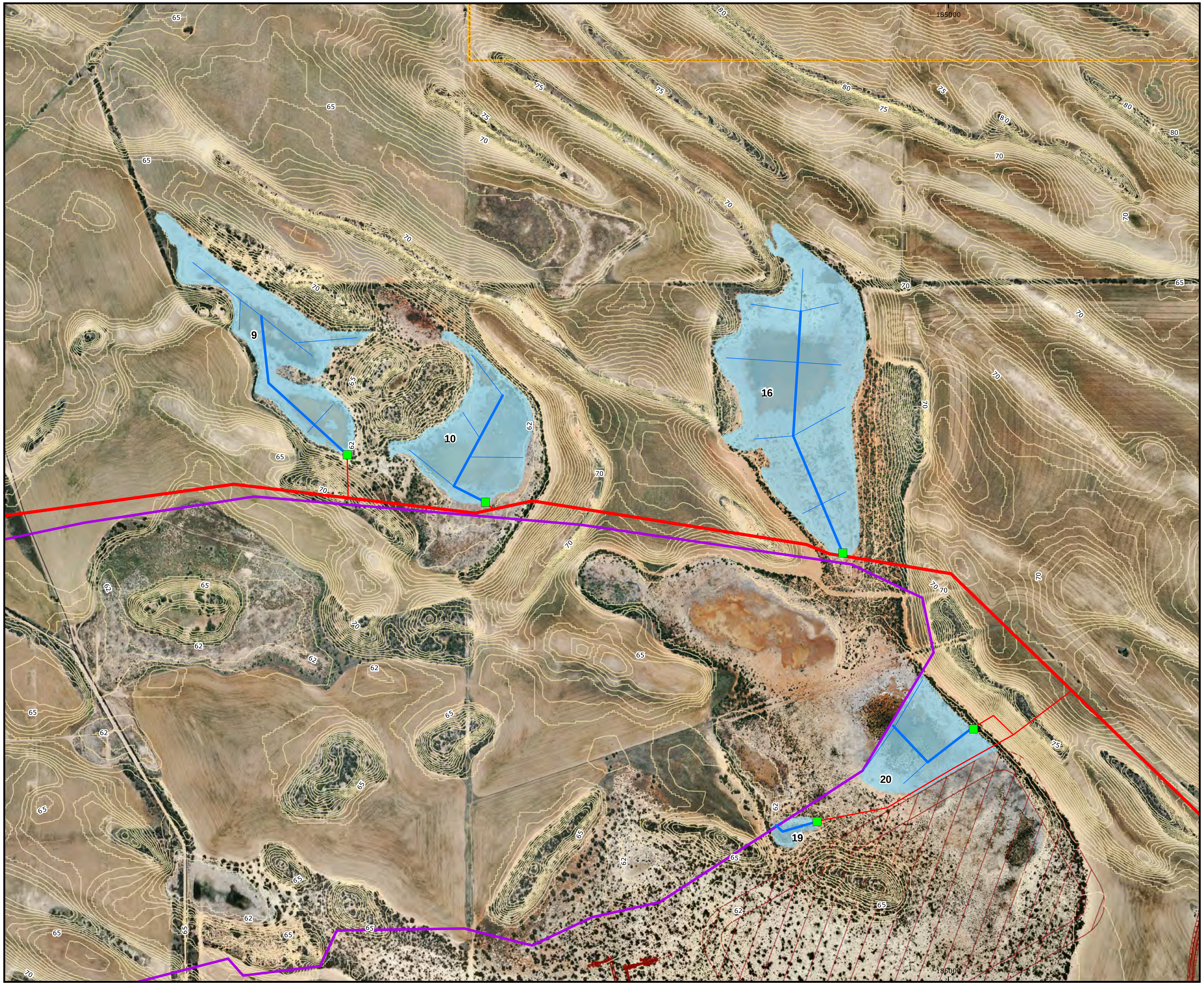
Table 22: Swales S9, S10, S16, S19 and S20 drain pipes and trench drain design

Swale	Dewatering Design Flow (L/s)	Main Trench Dimensions (m)	Secondary trench design flow (l/s)	Secondary Trench Dimensions (m)
S9	16.8 l/s	0.5x0.5	16.8/4 = 4.2	0.3x0.3
S10	9.1 l/s	0.5x0.5	9.1/4 = 2.3	0.3x0.3
S16	28.8 l/s	0.5x0.5	28.8/8 = 3.6	0.3x0.3
S19	0.4 l/s	0.3x0.5	0.4	0.3x0.3
S20	16.8 l/s	0.5x0.5	16.8/5 = 3.4	0.3x0.3

The drainage sumps should be located outside of the swale extent to facilitate access and operation. They are designed as open excavated sumps 1.5m x 1.5m and variable depth ranging from 0.5 to 2 m, depending on site conditions.

Diesel pumps installed adjacent to each sump will discharge to a pipe network. The designed pipeline concept arrangement can be seen in Figure 26, as well as the configuration of the trench drains and dewatering sumps. The recommend pipes are polyethylene pipes (PE100, PN10) with nominal diameter ranging from DN110 (Swales S10 and S19) to DN160 (S9, S16 and S20). The pipe diameters have been selected to minimise hydraulic head loss, keeping flow velocities below 2 m/s. These pipes will connect to the main dewatering pipeline from the Pit to the Mine Process Pond.

For the purpose of input to the site balance model (to be developed by others with input from this report) the monthly volumes to be managed have been calculated using the CEWB model for years 1957 (lowest annual rainfall recorded), the average year (statistically generated) and 1968 (highest annual rainfall recorded and with an estimated ARI of 100 years, giving a probability of occurrence of about 18% within the 20 year mine life). The results of the incremental monthly volumes are included in Table 23 and can be used as an input for an overall mine water balance.



LEGEND

- Pumping Sump
- Main Drainage Trench
- Secondary Drainage Trench
- Main Pipeline to Mine Process Plant
- PE100 PN10 Pipe
- Contours (50cm)
- October Updated Mine 2014108
- Pit Limits
- Mine Swales
- Proposed Mine Lease Boundary

N

200 0 200 400

Metres

APPROX SCALE 1:10,000 @ A3

GDA 1994 MGA Zone 54

RPS

FIGURE 26

Swale Drainage Infrastructure Layout

Table 23: Swales S9, S10, S16, S19 and S20 monthly incremental volumes

Contributing Catchment	Y1	Y2	Y5	Y8	Y15	Y18 / Y21
	1957 (dry year) monthly surface water volumes (ML)					
January	0.0	0.0	0.0	0.0	0.0	0.0
February	0.0	0.0	0.0	0.0	0.0	0.0
March	0.0	0.0	0.0	0.0	0.0	0.0
April	0.0	0.0	0.0	0.0	0.0	0.0
May	0.0	0.0	0.0	0.0	0.0	0.0
June	0.4	0.4	0.4	0.4	0.4	0.4
July	4.0	3.9	3.7	3.7	3.6	3.6
August	0.0	0.0	0.0	0.0	0.0	0.0
September	0.0	0.0	0.0	0.0	0.0	0.0
October	0.0	0.0	0.0	0.0	0.0	0.0
November	0.0	0.0	0.0	0.0	0.0	0.0
December	0.0	0.0	0.0	0.0	0.0	0.0
Total Annual	**4.4**	**4.3**	**4.1**	**4.1**	**3.9**	**3.9**
	Average monthly surface water volumes (ML)					
January	0.0	0.0	0.0	0.0	0.0	0.0
February	0.0	0.0	0.0	0.0	0.0	0.0
March	0.0	0.0	0.0	0.0	0.0	0.0
April	0.0	0.0	0.0	0.0	0.0	0.0
May	1.0	0.9	0.9	0.9	0.9	0.9
June	9.0	8.9	8.5	8.4	8.2	8.1
July	12.9	12.6	12.2	12.0	11.7	11.6
August	0.5	0.5	0.5	0.5	0.5	0.5
September	0.0	0.0	0.0	0.0	0.0	0.0
October	0.0	0.0	0.0	0.0	0.0	0.0
November	0.0	0.0	0.0	0.0	0.0	0.0
December	0.0	0.0	0.0	0.0	0.0	0.0
Total Annual	**23.4**	**22.9**	**22.1**	**21.8**	**21.2**	**21.1**
	1968 (wet year) monthly surface water volumes (ML)					
January	0.0	0.0	0.0	0.0	0.0	0.0
February	0.0	0.0	0.0	0.0	0.0	0.0
March	0.0	0.0	0.0	0.0	0.0	0.0
April	0.0	0.0	0.0	0.0	0.0	0.0
May	49.8	48.8	47.0	46.4	45.1	44.9
June	361.3	353.7	340.4	336.7	327.1	325.1
July	151.8	148.6	143.1	141.5	137.5	136.6
August	16.9	16.6	16.0	15.8	15.3	15.2
September	0.0	0.0	0.0	0.0	0.0	0.0
October	0.0	0.0	0.0	0.0	0.0	0.0
November	0.0	0.0	0.0	0.0	0.0	0.0
December	0.0	0.0	0.0	0.0	0.0	0.0
Total Annual	**580.0**	**567.7**	**546.4**	**540.4**	**525.0**	**521.8**

6.2 Infrastructure protection

As discussed in Section 5.4, a number of mining assets could affect surface water drainage, namely the IWL and some sections of the excavated pits. As detailed in this report, no surface water flows are expected within the mine lease and no water ponding is expected outside the swales and low lying areas. However, it is recommended that good engineering practice be applied to deliver a degree of protection in three critical areas, notably the north and south sides of the IWL (and associated drain and service road) and the western end of the open pits. These drain alignments run across the dune and swale system and are influenced by contributing catchments, CD1 to CD4, as shown in Figure 23.

It is expected that the IWL peripheral drain will be constructed following contours of the natural landform as it intersects with many dunes and swales. The gradients expected on this will, in some parts, require erosion control. It is recommended that the foundation embankment on which the IWL drain and service road will be constructed on be protected against erosion in the low lying areas as a minimum. The protection is designed to provide erosion control of the embankment in the improbable event of ponding against it, but has also other benefits enhancing embankment stability and preventing scouring due to direct rain.

The embankment protection would typically consist of a layer of rock with a minimum recommended particle size (D_{50}) of 75mm, and a minimum thickness of the layer 150mm. Depending on the material used to form the embankment, a geotextile may be required.

The bund to be constructed around the open pits and which is not within scope for this study may also require similar protection, especially in the southern edge of Murphys pit in contact with swales S19 and S20. The intention should be to protect the bund in case there is a failure of the pumping and drainage system described in section 6.1 or in the event that pumping is actually not performed on time. In that case the protection may need to cover a length of about 325 m of bund, up to 0.5m high. Similarly it is recommended that the bund located in the west side of the open pit, which intercepts drainage from catchment CD1, have a rock protection in the unlikely case of surface flows and ponding against it.

7 Interaction with SysCAD Site Mine Water Balance

The estimated surface water volumes which can be used as input to an overall mine water balance can be found in the following tables of this report:

- For the monthly surface water volumes drained from the open pits, refer to Table 15 in section 5.3.1.
- For the monthly surface water volumes from drained swales S9, S10, S16, S19 and S20, refer to Table 23 in section 6.1.

8 References

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Appendix A Site Visit

APPENDIX A: SITE VISIT

The following is a summary of the findings and conclusions during and after the site visit conducted on 3rd of May 2013. The attendees to the site visit were Ben Jeuken (IR), Tim Scholz (IR), Richard Clark (independent consultant), Hugh Middlemis (RPS) and Alfonso Perez (RPS)

The site visit comprised of interviews with local people and a field visit during which an infiltration test was performed. Prior to the visit a questionnaire was distributed among the local residents in an effort to gather as much local knowledge as possible. Some of these questionnaires have been returned with valuable information which has been also incorporated in this summary.

1.1.1 Land Owner and Local Council Engineer interviews:

The following is a summary of the conversations maintained with the local people were interviewed during the site visit:

- Interview with Kevin Murphy (land owner):
  - He has not completed the questionnaire.
  - He does not recall any large flooding within the Warramboo area.
  - Remembers minor flooding within the area in the 1956, 1968 and 1992, where some roads flooded and there were some access restrictions. The depth of the flooding varied but never greater than 0.5 m at the lowest points (impoundments).
  - The swales and salinas occasionally fill up in winter, the water residence time, depending on the climatologic conditions (rainfall and evaporation) of each particular year, can be several weeks to few months.
  - He identifies a location near his property in which water ponds regularly during most of the winter months.
  - There are no creeks or water courses in the area; he believes the water reaches the low points by percolation sub-surface flow.
- Interview with Colin Sampson (land owner):
  - He has completed the questionnaire.
  - He verifies that swales and salinas at the low areas fill up with water for several weeks in winter.
  - He is unclear on how water gets to the low areas, he is not sure if there is any superficial runoff involved.
  - He confirms that water level at the swales is shallow, only some centimetres.
  - He confirms that the swales drain local catchments and do not connect to each other.
  - Conducted a short visit to one of the low laying impoundment areas.
- Interview with Andrew Buckham and Neil Haines (Wuldinna District Council):
  - They will complete the questionnaire and submit by mail.
  - They confirm there are no water courses within the area.
  - They confirm water ponds seasonally in swales and salinas.
  - The Tod Highway does not have local drainage or culverts across. It is built above the general ground level at the lower points, so water impounds at both sides of the road.
  - There have been no road closures due to flooding in the last five years.
  - Summer rain events produce temporary bi-dimensional runoff, which eventually infiltrates the ground without creating any impoundment.
  - During winter rising water levels in the low areas last for few months, drying out in spring.
  - Overall the country is very sandy, with clay patches and calcrete underlying in some areas.
  - They confirm that there are not known hydrology studies within the region.
  - The largest rainfall event in recent times was in 1992 when up to 300 mm of water were observed to pond in the swales and salinas across the region.
  - There is no recollection of any runoff from rainfall occurring in the last 12 months

1.1.2 Infiltration Test:

An infiltration test was carried out using a double ring infiltrometer and following the recommendations of the Standard Test Method ASTM D 3385-03. The test was performed about 7 km east of Warramboo, next to the future Murphy Pit Shell border. The location where the test was performed is shown in the following figures.

Figure 1: Infiltration test location

Figure 2: Infiltration test site

The variation of the water depth in the inner ring was measured at 1 minute intervals during two consecutive periods of six minutes each. The data logged was analysed using the Philip equations, 1957, to infer the saturated hydraulic conductivity of the soil at this location. The analisys is presented in Appendix A to this document.

The infiltration test used to estimate the saturated hydraulic conductivity K of the sandy soils found at the project site. This was found to be 1.2×10^{-4} m/s, which is classified as medium permeability with good drainage conditions, typical of clean sands with little content of fines (Casagrande and Fadum, 1940)

Further details of the infiltration test can be found in Appendix A to this memorandum.

1.1.3 Final notes and conclusions:

Two conclusions related to the mine site hydrology were taken after interpreting the information gathered:

- In winters the shallow low lands and swales usually fill up for several weeks, the maximum expected water depth to be about 300 mm. This is due to accumulation of water in the sub-surface, increasing soil moisture content, which eventually filtrates to the more impermeable low lying areas. During winter, low evaporation and higher than average total rainfall keep recharging the impoundment volumes that can last for several weeks to few months.
- Extreme rainfall events, recorded during the summer months, have caused ephemeral bi-dimensional runoff with without defined water courses. Large rainfall intensities will saturate the soil in a short period of time, generating runoff that could last for several hours and temporary impoundment in low lying areas for few hours or days.

Appendix B Site Infiltration Test

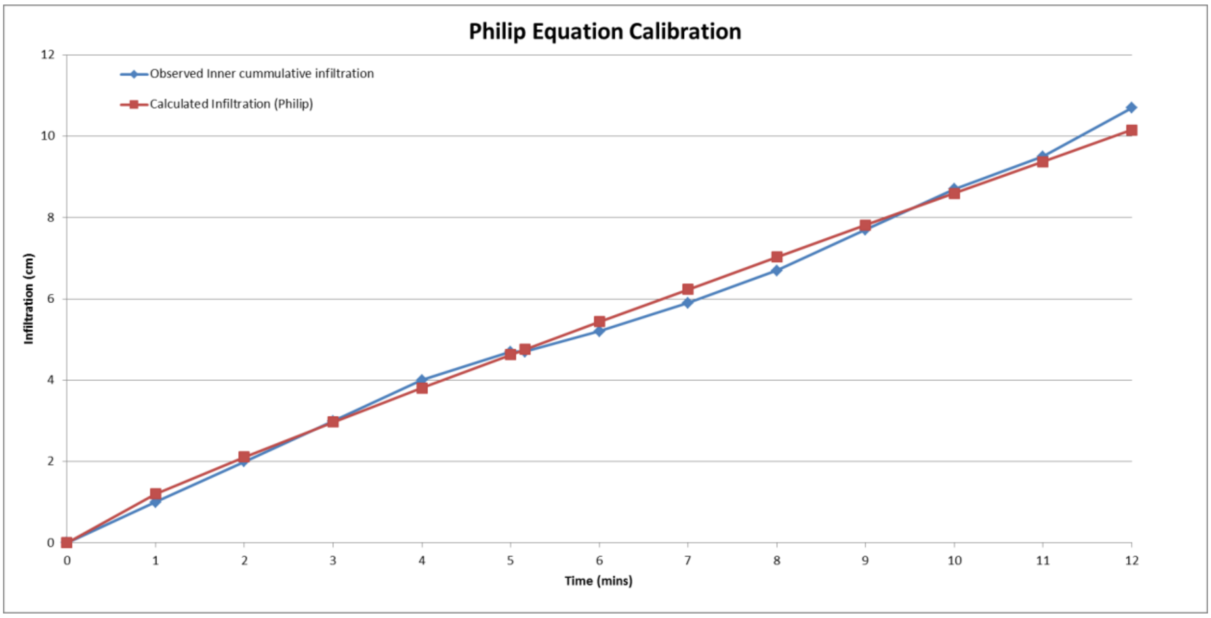
APPENDIX B: INFILTRATION TEST RESULTS

Philip equations, 1957

$$i(t) = St^{\frac{1}{2}} + At \qquad (1)$$

$$v(t) = \frac{1}{2}St^{-\frac{1}{2}} + A \qquad (2)$$

					Ring Height (cm)				
		Logged data			21	20			
time (mins)		Inner meassure	Outer meassure		Inner Water depth	Outer water depth		Inner Infiltration	Observed Inner cummulative infiltration
									i(t)
Mins		cm	cm		cm	cm		cm	cm
0		15	15		6	5		0	0
1		16			5	20		1	1
2		17	16.8		4	3.2		1	2
3		18	17.5		3	2.5		1	3
4		19	18.2		2	1.8		1	4
5		19.7	19		1.3	1		0.7	4.7
5.16		15	15		6	5		0	4.7
6		15.5	15.5		5.5	4.5		0.5	5.2
7		16.2	16		4.8	4		0.7	5.9
8		17	17		4	3		0.8	6.7
9		18	17.5		3	2.5		1	7.7
10		19	18.5		2	1.5		1	8.7
11		19.8	19		1.2	1		0.8	9.5
12		21	20		0	0		1.2	10.7



	Sorptivity	S=	0.505
	Parameter	A=	0.7
	Sat. hyd. Conductivity	**K* (m/s) =**	**1.20E-04**
time (mins)	Calculated Infiltration (Philip)	Infiltration rate	Infiltration rate
	i(t)	v(t)	v(t)
Mins	cm	cm/seg	m/seg
0	0.00		
1	1.21	1.59E-02	1.59E-04
2	2.11	1.46E-02	1.46E-04
3	2.97	1.41E-02	1.41E-04
4	3.81	1.38E-02	1.38E-04
5	4.63	1.35E-02	1.35E-04
5.16	4.76	1.35E-02	1.35E-04
6	5.44	1.34E-02	1.34E-04
7	6.24	1.33E-02	1.33E-04
8	7.03	1.32E-02	1.32E-04
9	7.82	1.31E-02	1.31E-04
10	8.60	1.30E-02	1.30E-04
11	9.37	1.29E-02	1.29E-04
12	10.15	1.29E-02	1.29E-04
14	11.69	1.28E-02	1.28E-04
15	12.46	1.28E-02	1.28E-04
20	16.26	1.26E-02	1.26E-04
25	20.03	1.25E-02	1.25E-04
30	23.77	1.24E-02	1.24E-04
35	27.49	1.24E-02	1.24E-04
40	31.19	1.23E-02	1.23E-04
45	34.89	1.23E-02	1.23E-04
50	38.57	1.23E-02	1.23E-04
55	42.25	1.22E-02	1.22E-04
60	45.91	1.22E-02	1.22E-04
90	67.79	1.21E-02	1.21E-04
120	89.53	1.21E-02	1.21E-04
150	111.18	1.20E-02	1.20E-04
180	132.78	1.20E-02	1.20E-04

* K is equal to the long term infiltration rate V(t) (horizontal asymptote)

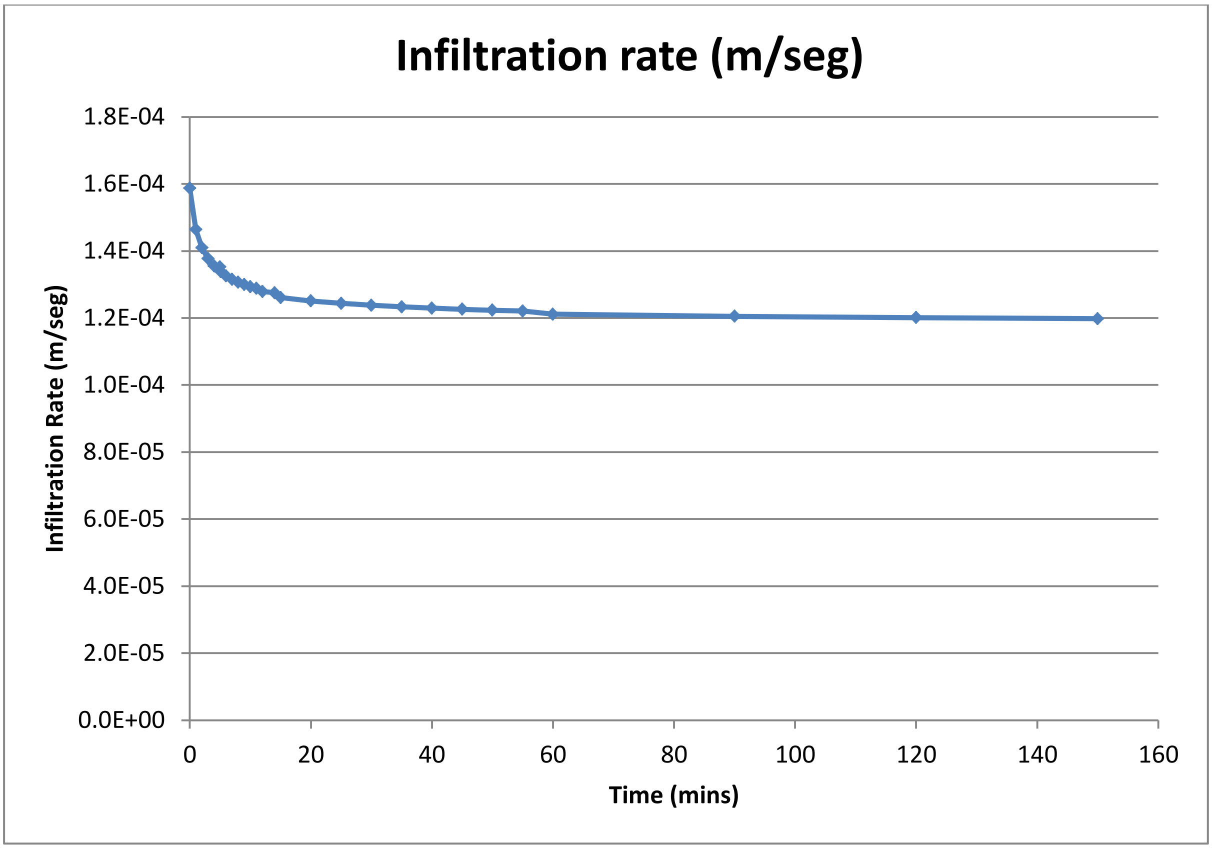


Table 4.1 TYPICAL PERMEABILITY VALUES FOR SOILS

Coefficient of permeability (log scale)	m/s	10^{-11}	10^{-10}	10^{-9}	10^{-8}	10^{-7}	10^{-6}	10^{-5}	10^{-4}	10^{-3}	10^{-2}	10^{-1}	1
	cm/s	10^{-9}	10^{-8}	10^{-7}	10^{-6}	10^{-5}	10^{-4}	10^{-3}	10^{-2}	10^{-1}	1	10	100
	ft/s	10^{-10}	10^{-9}	10^{-8}	10^{-7}	10^{-6}	10^{-5}	10^{-4}	10^{-3}	10^{-2}	10^{-1}	1	

Permeability:	Practically impermeable	Very low	Low	Medium	High
Drainage conditions:	Practically impermeable	Poor	Good		

Typical soil groups:

GC→	GM→		SM	SW→	GW→
CH	SC, MH, MC–CL	SM–SC		SP→	GP→

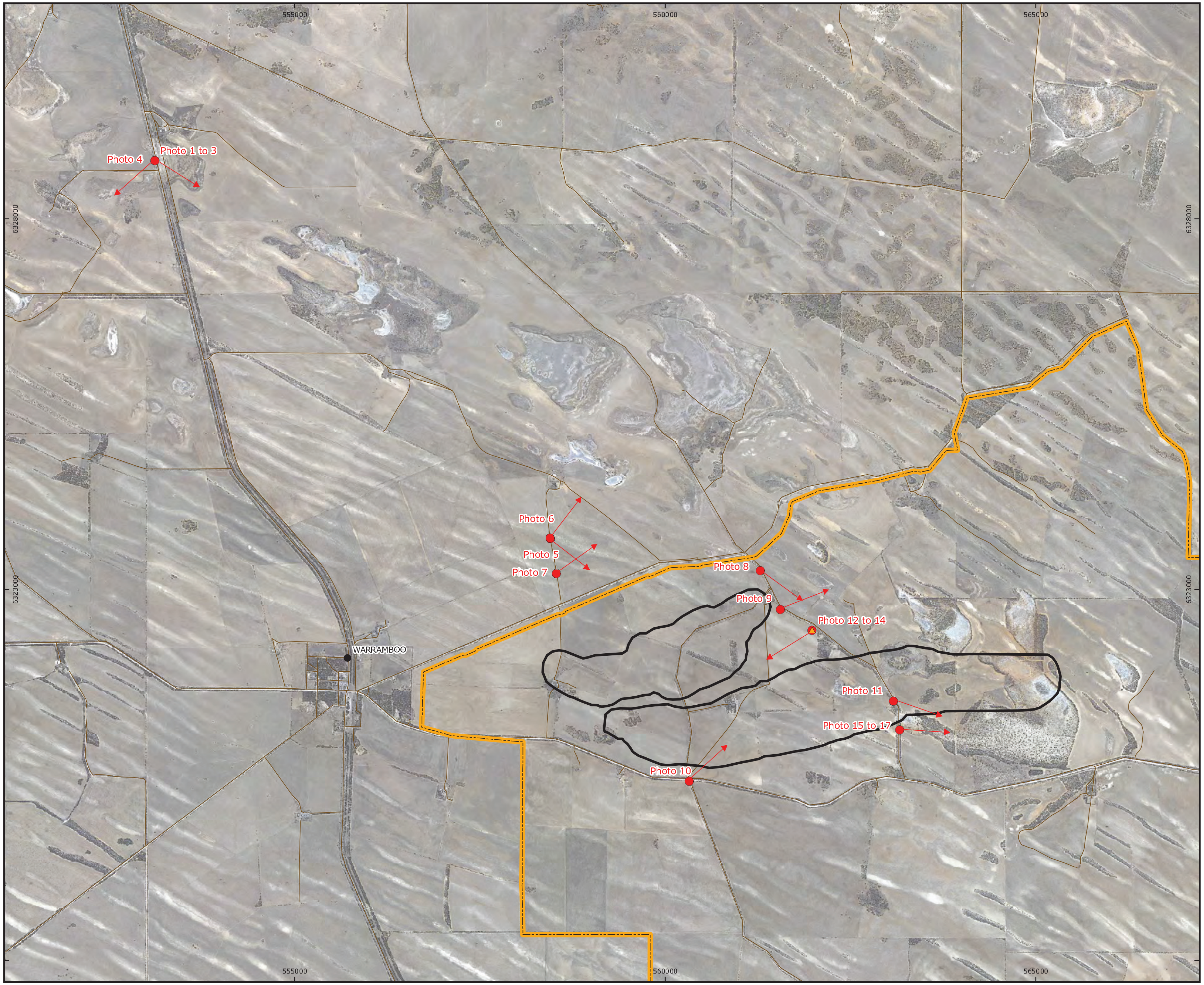
Soil types:	Homogeneous clays below the zone of weathering	Silts, fine sands, silty sands, glacial till, stratified clays	Clean sands, sand and gravel mixtures	Clean gravels
		Fissured and weathered clays and clays modified by the effects of vegetation		

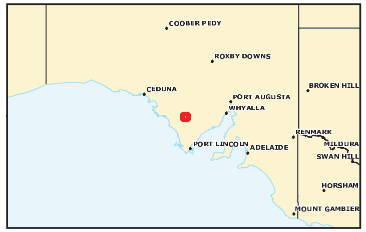
Note: the arrow adjacent to group classes indicates that permeability values can be greater than the typical value shown.

Typical permeability values for soil from Casagrande and Fadum (1940);

Source: Carter M and Bentley SP, 1991, Correlations of Soil Properties, Pentech Press, London

Appendix C Site Photo Reportage





LEGEND

- Locality
- Infiltration Test Site
- Photo Site
- Photo Direction
- Road
- Pit Shells
- Mine Lease Boundary

N

1 0 1 2
Kilometers

APPROX SCALE 1:50,000 @ A3

DATA SOURCES

RPS

RPS Aquaterra

FIGURE 1

Iron Road
Photo Sites

A258_001 Rev: A Produced: Loader Reviewed: Loader Date: 17/06/2013

Photo 1: Swale next to Tod Highway, main pipeline and railway between Warramboo and Kyancutta Eastern side view

Photo 2: Swale next to Tod Highway, main pipeline and railway between Warramboo and Kyancutta Eastern side view

Photo 3: Swale next to Tod Highway, main pipeline and railway between Warramboo and Kyancutta

Eastern side view

Photo 4: Swale next to Tod Highway between Warramboo and Kyancutta

Western side view

Photo 5: Mine lease area, site of the future open pits

Undulated landscape of dunes on agricultural land

Photo 6: Fields northwest of the mine lease area

Undulated landscape of dunes on agricultural land

Photo 7: Fields northwest of the mine lease area

Undulated landscape of dunes on agricultural land

Photo 8: Mine lease area, east from North Pit and looking at the site of the future South Pit.

Photo 9: Mine lease area, looking at the site of the future crusher plant and area of installations.

Photo 10: Mine lease area, site of the future open pits

Photo 11: Mine lease area, site of the future open pits

Swales at the low lying areas show evidence of water pounding

Photo 12: Detail of the subsoil near the location of the infiltration test

Clean sand with little fine content, medium permeability.

Photo 13: Detail of the subsoil near the location of the infiltration test

Sandy loam with some non-plastic fines, low permeability

Photo 14: Location of the infiltration test

Photo 15: Extensive swale within the mine lease boundary show evidence of shallow water impoundment

Photo 16: Swale within the mine lease boundary show evidence of shallow water impoundment

Photo 17: Detail of surface of the swale

Silt and clay with medium plasticity (LL<50), expected to have very low permeability.

Appendix D Rainfall Data

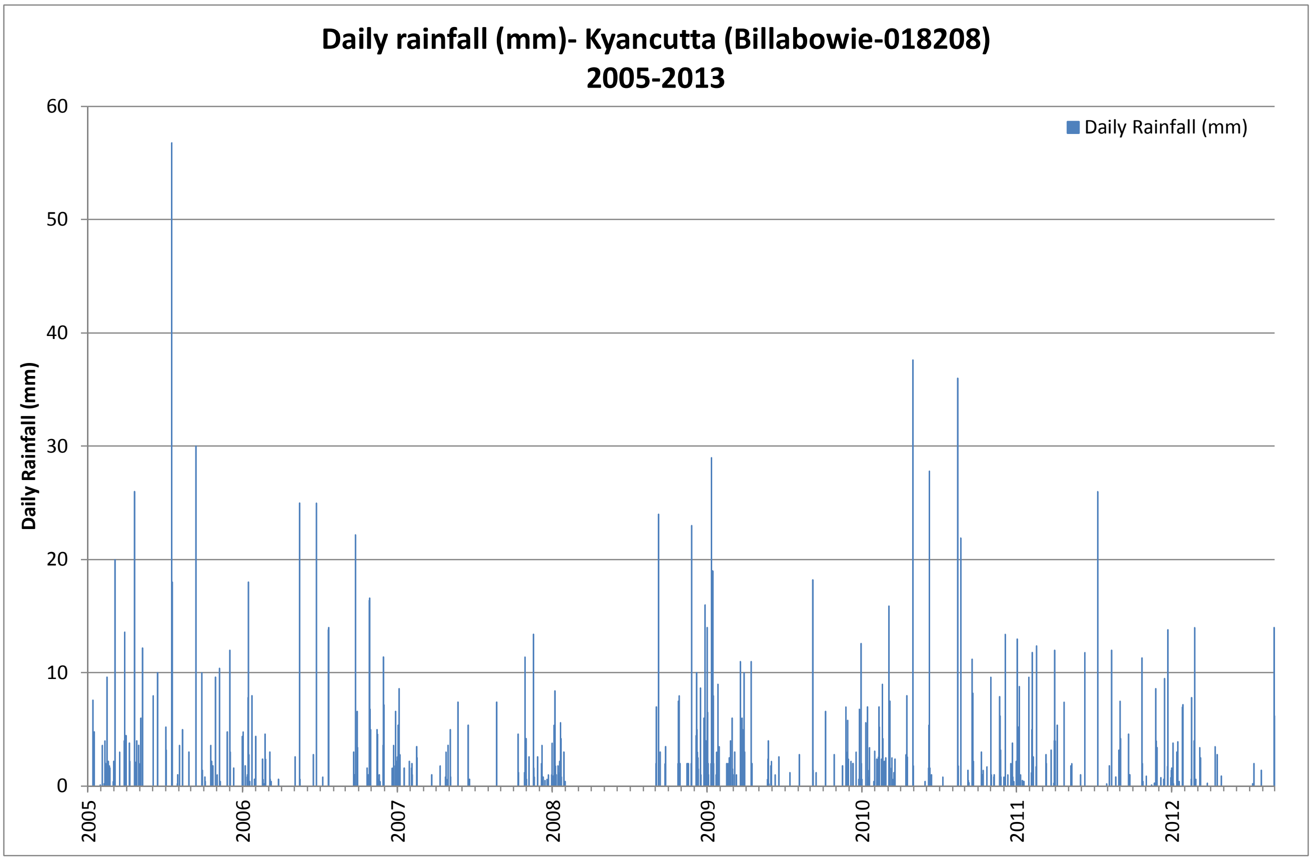


Figure D1: Daily rainfall at Kyancutta (Billabowie) station.

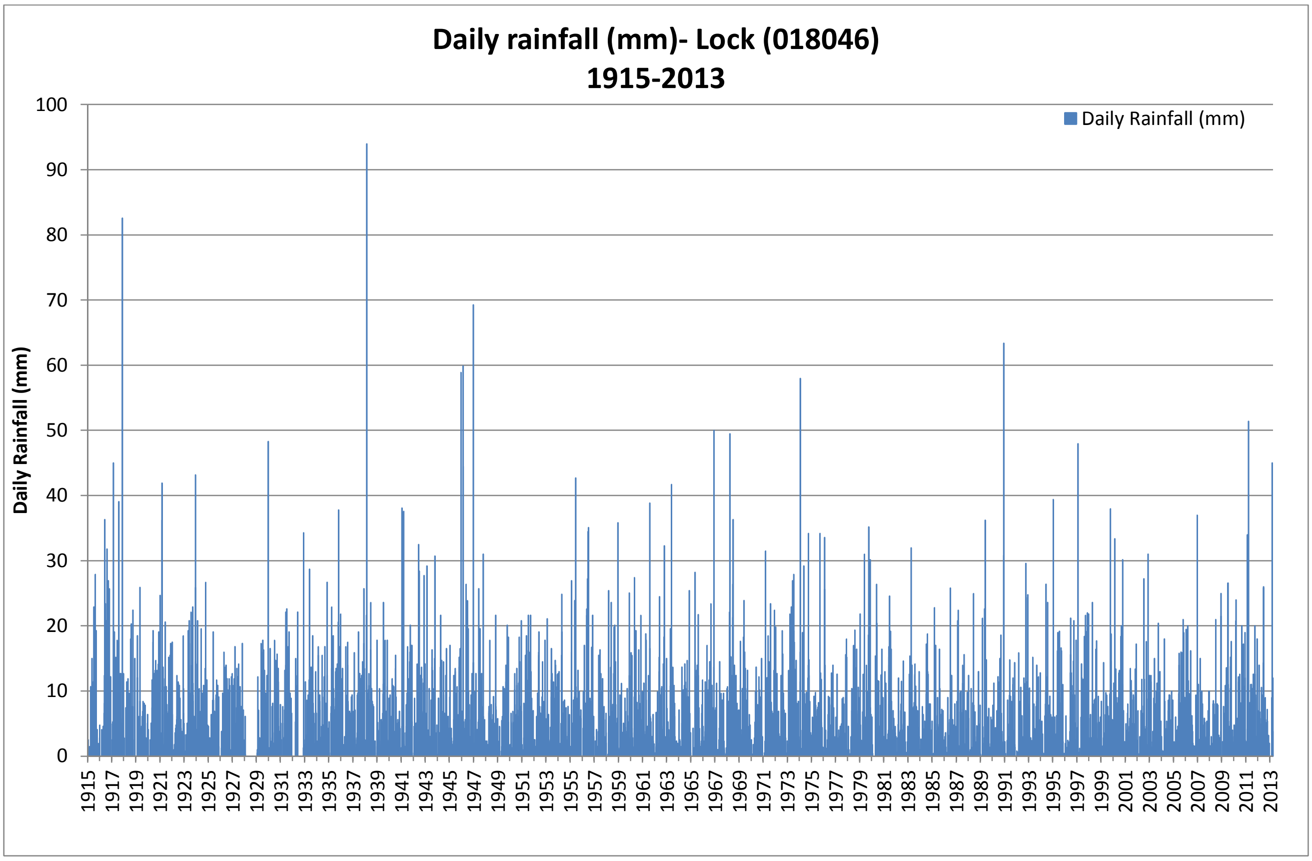


Figure D2: Daily rainfall at Lock station.

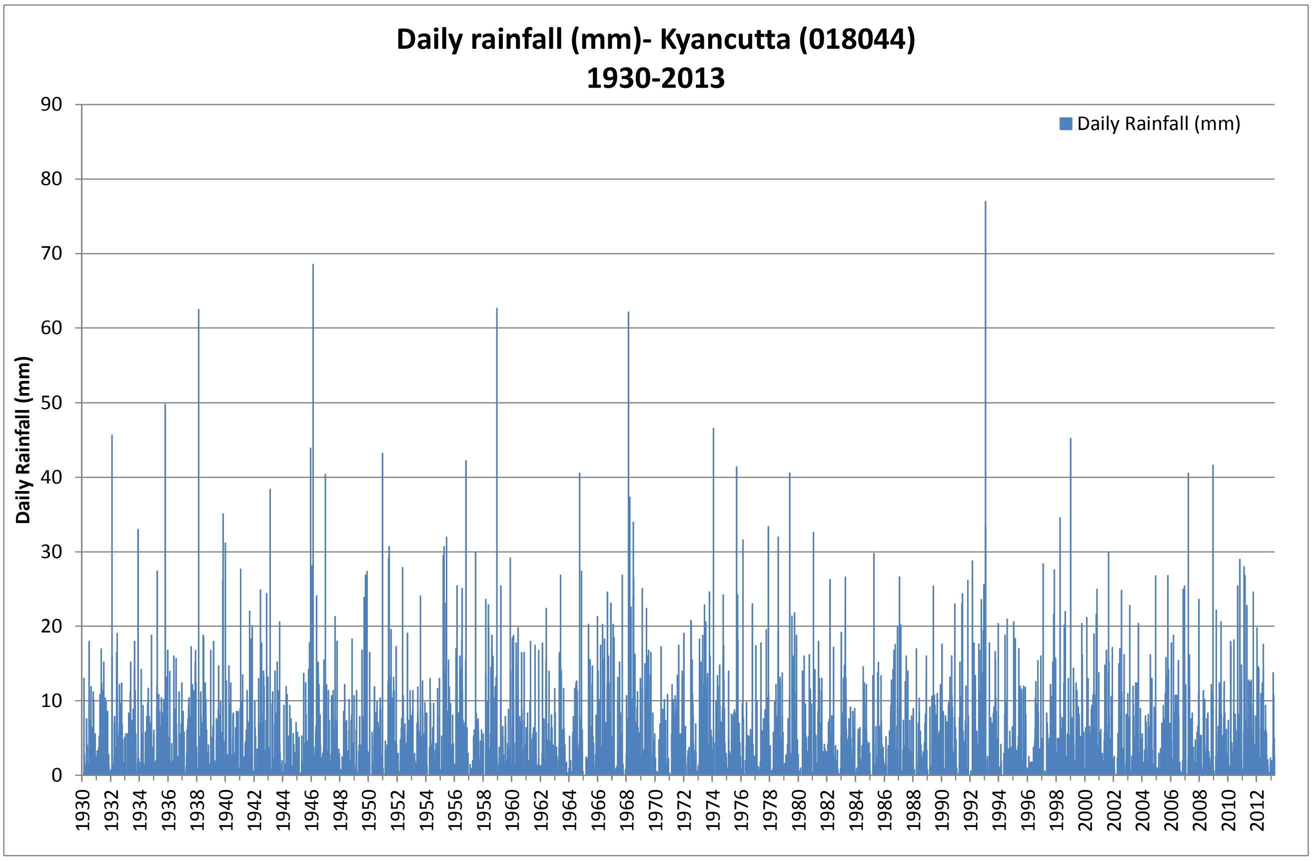


Figure D3: Daily rainfall at Kyancutta station.

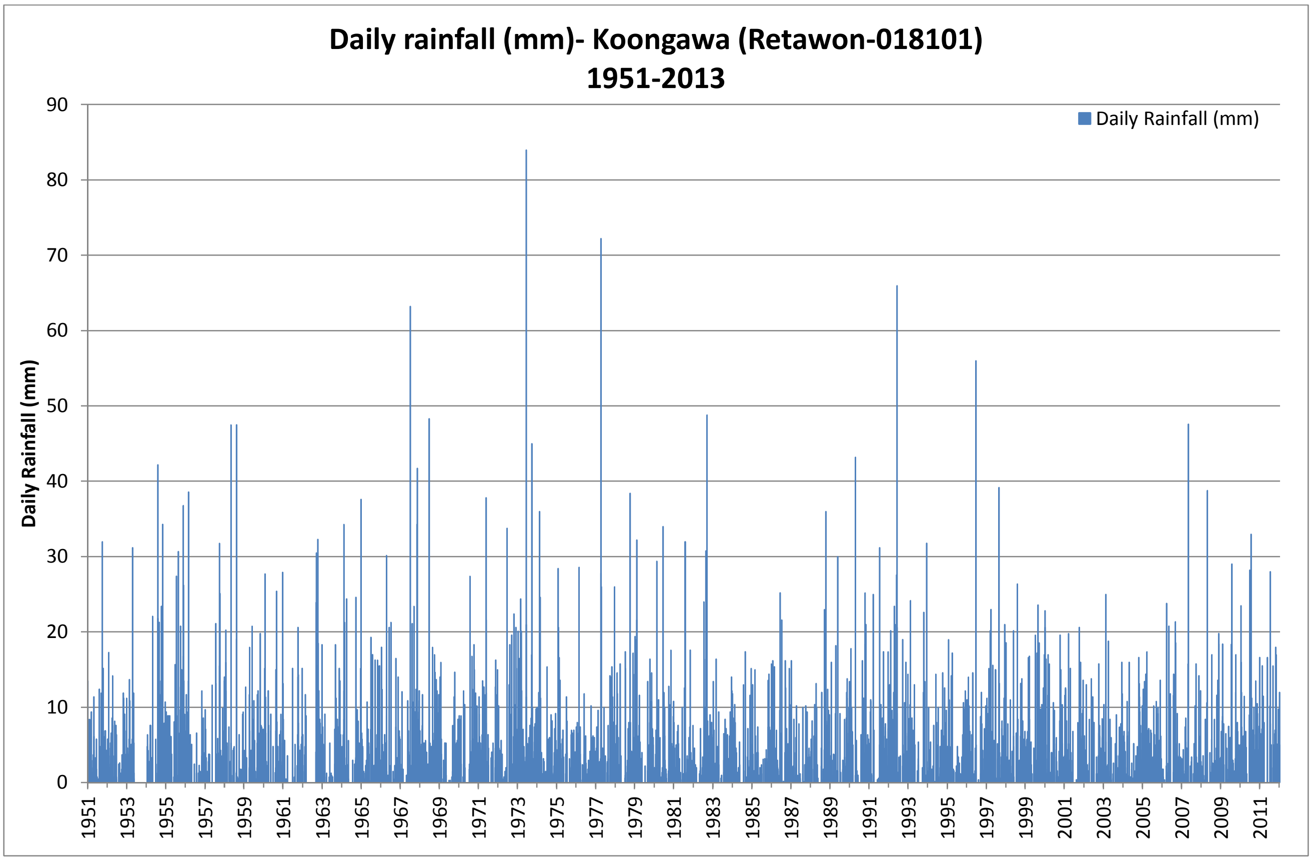


Figure D4: Daily rainfall at Koongawa (Retawon) station.

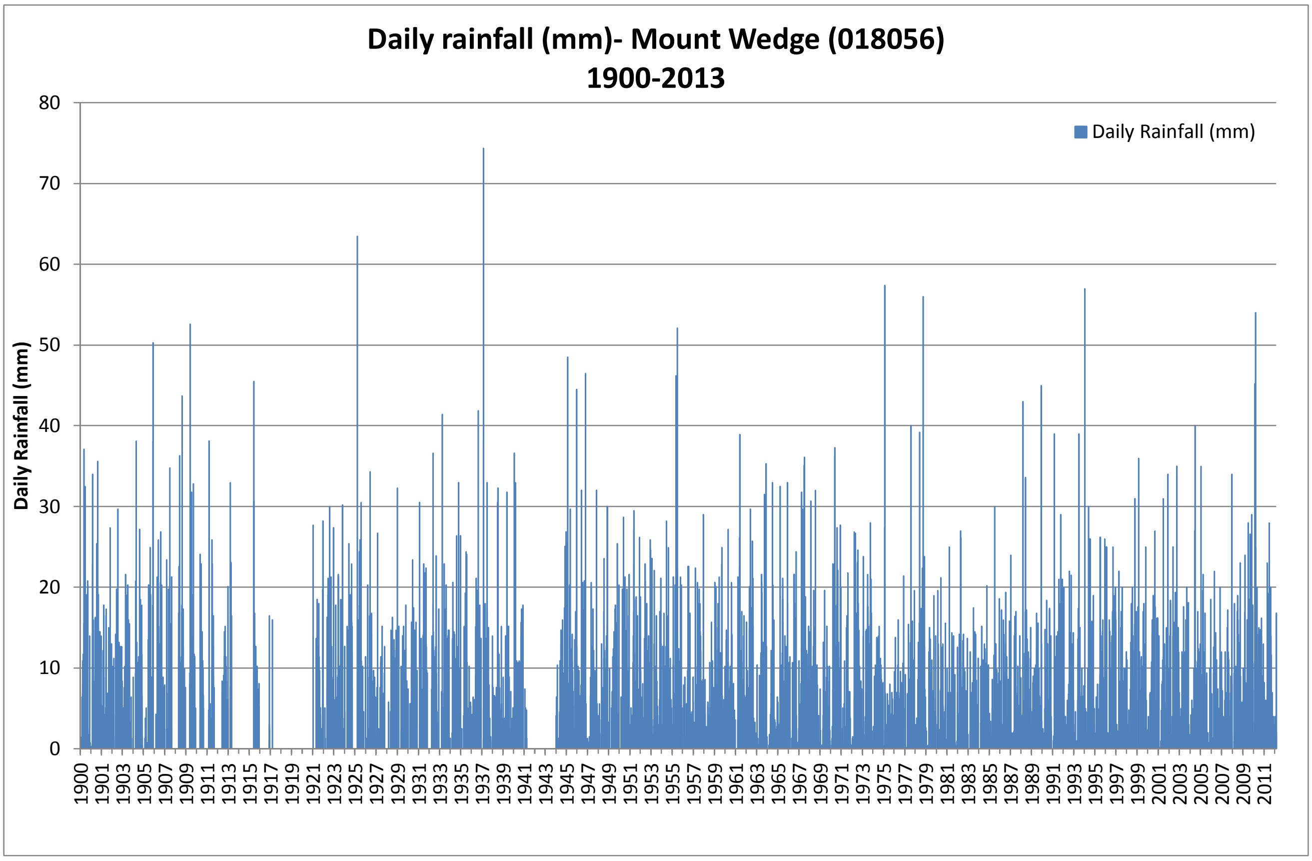


Figure D5: Daily rainfall at Mount Wedge station.

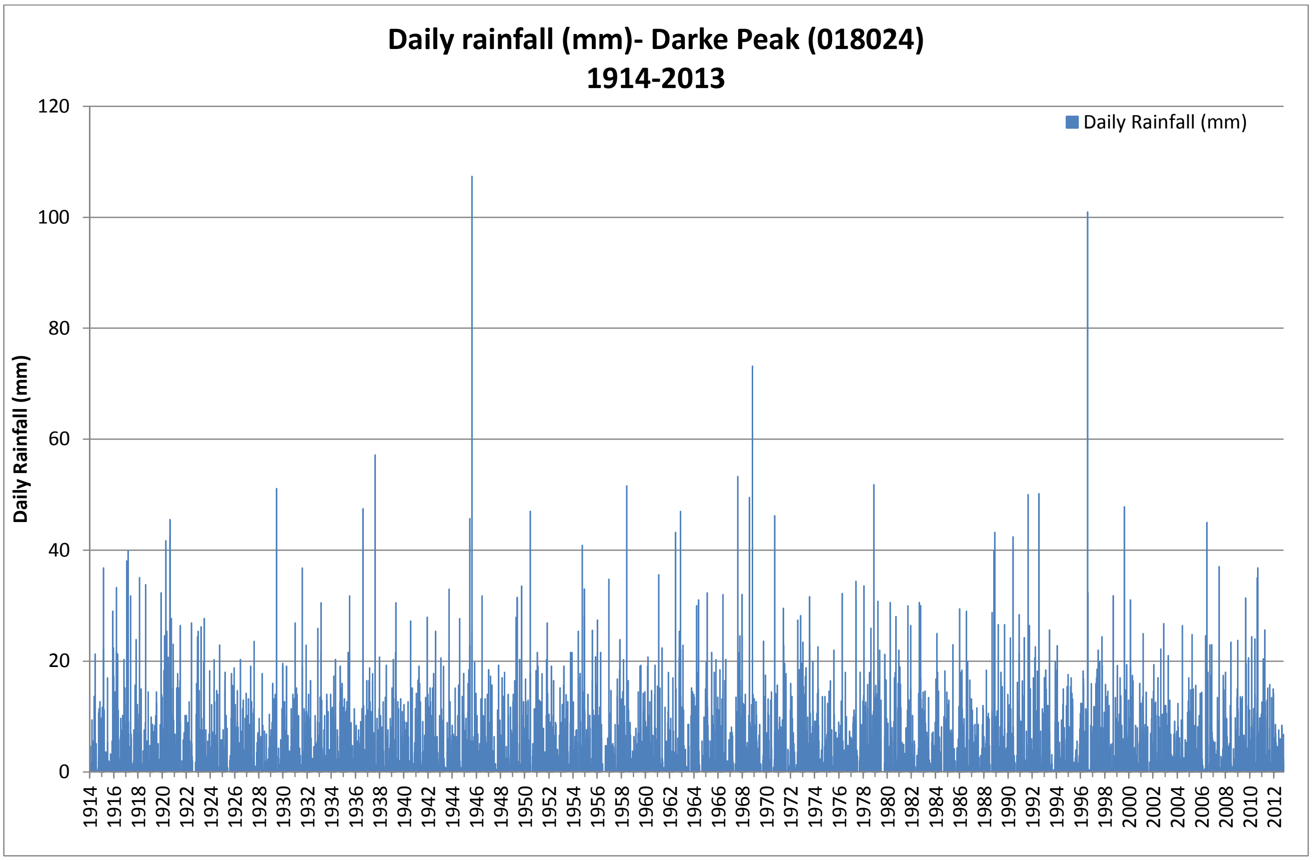


Figure D6: Daily rainfall at Darke Peak station.

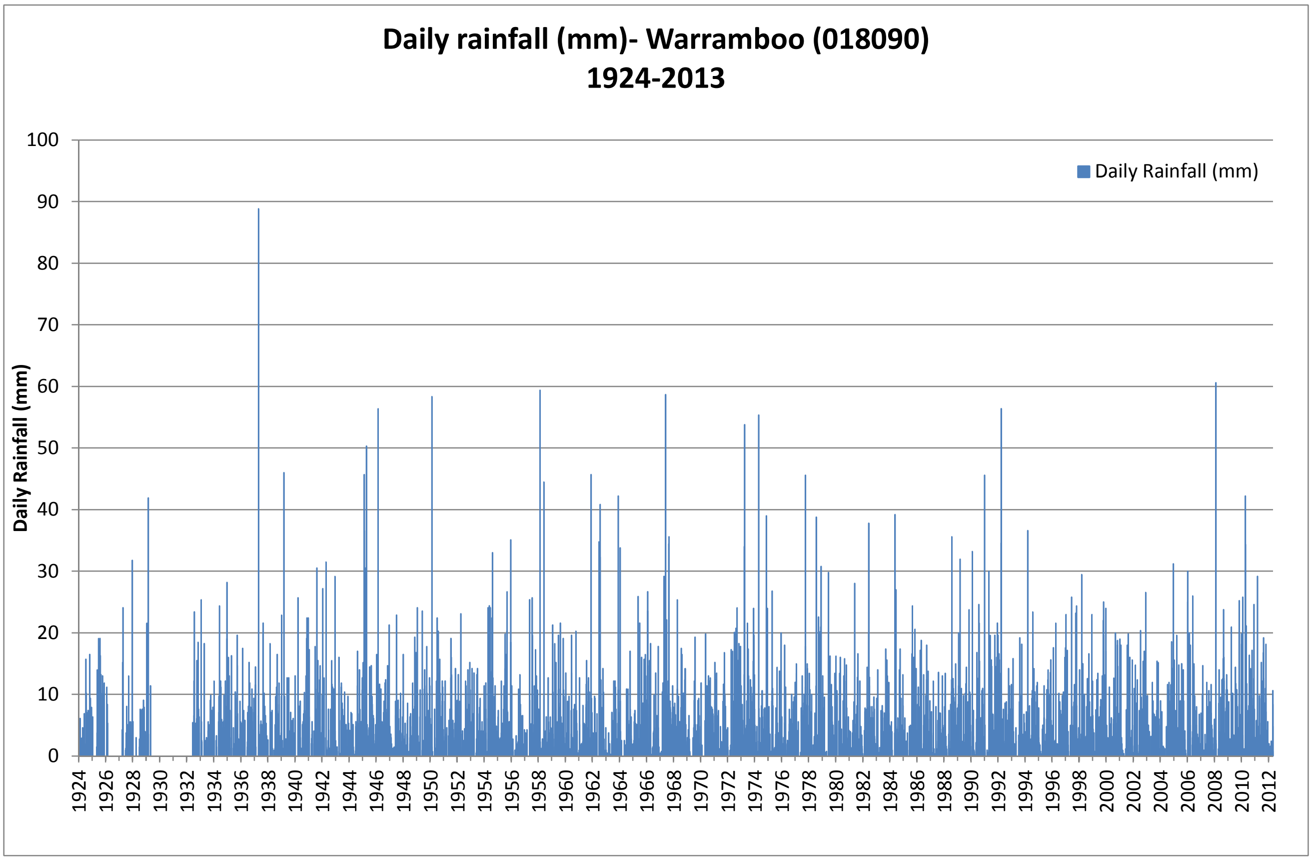


Figure D7: Daily rainfall at Warramboo station.

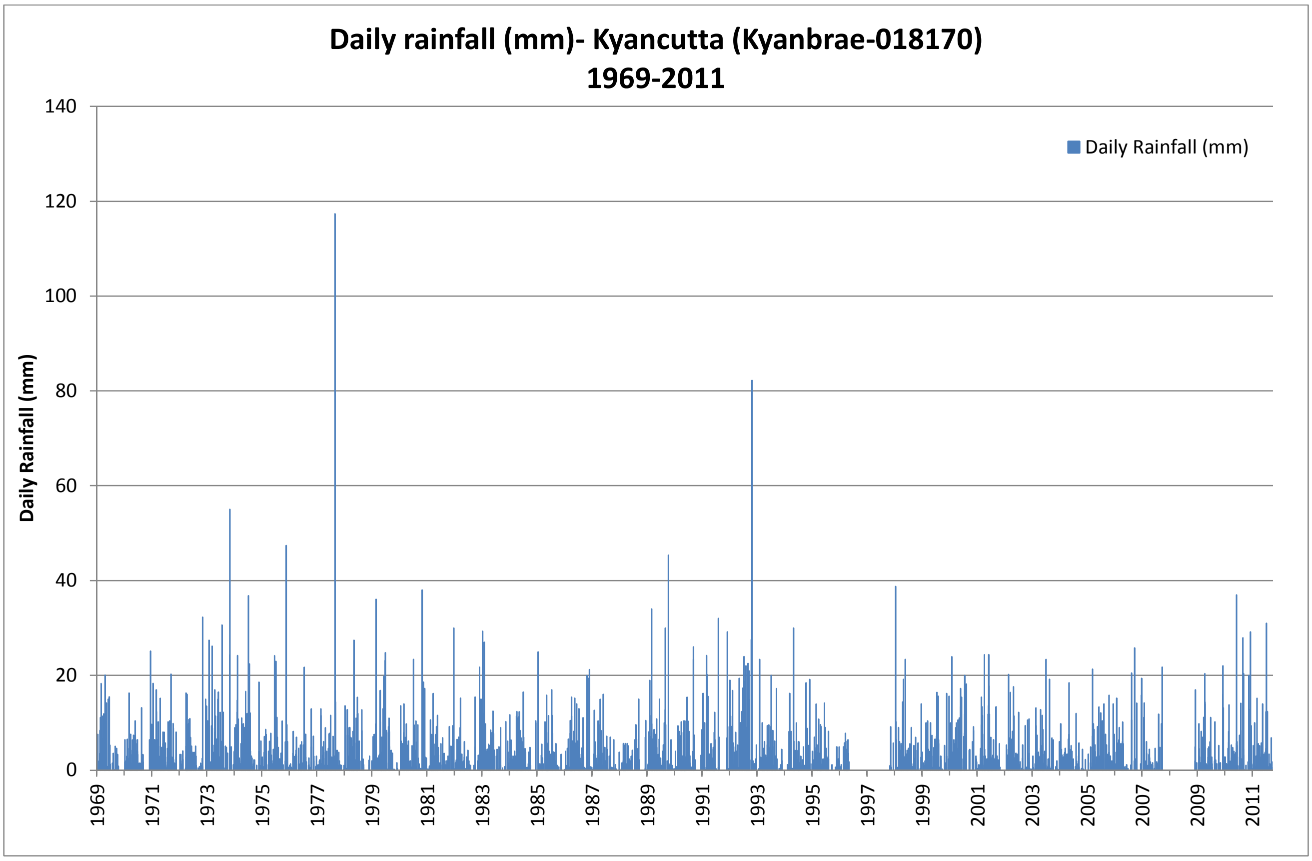


Figure D8: Daily rainfall at Kyancutta (Kyanbrae) station.

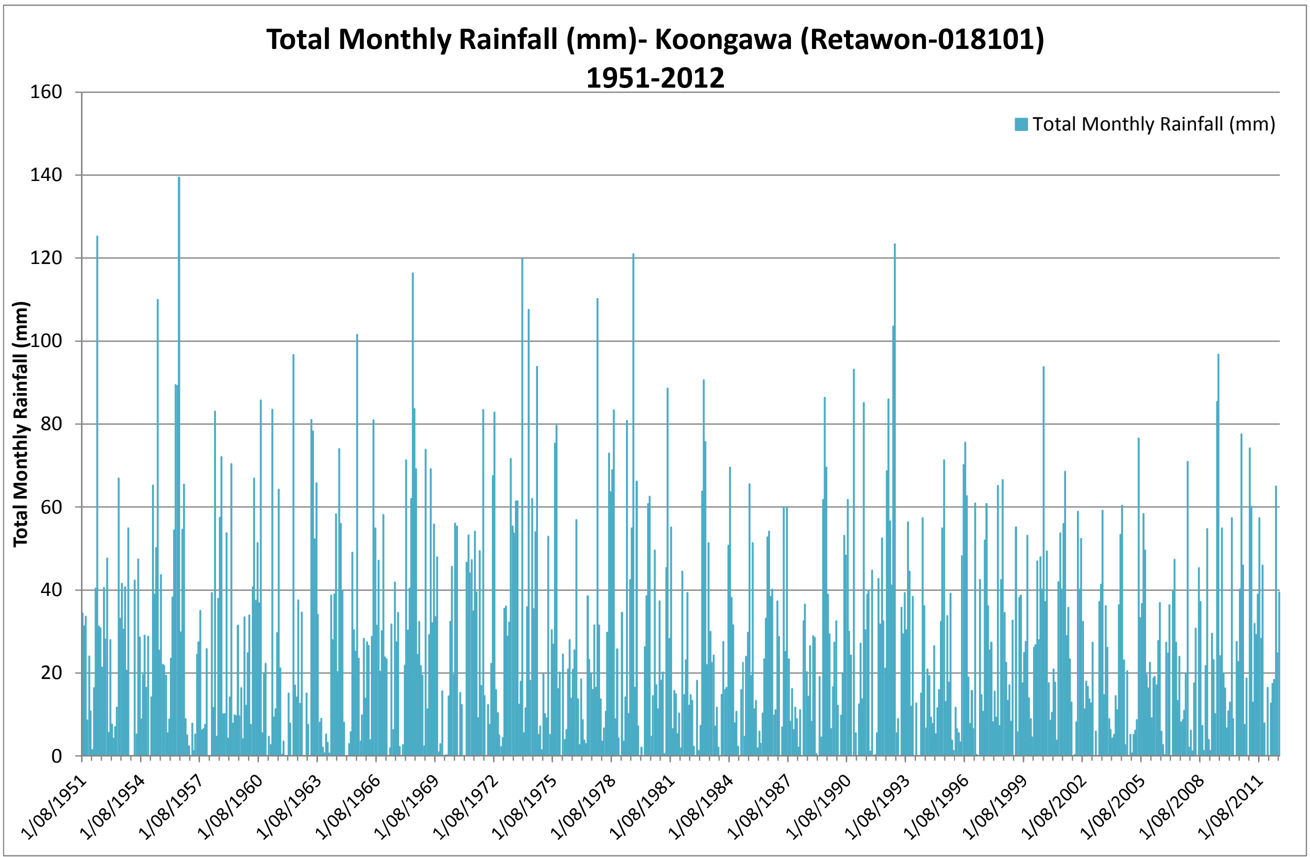


Figure D9: Total monthly rainfall at Koongawa Retawon station (018101).

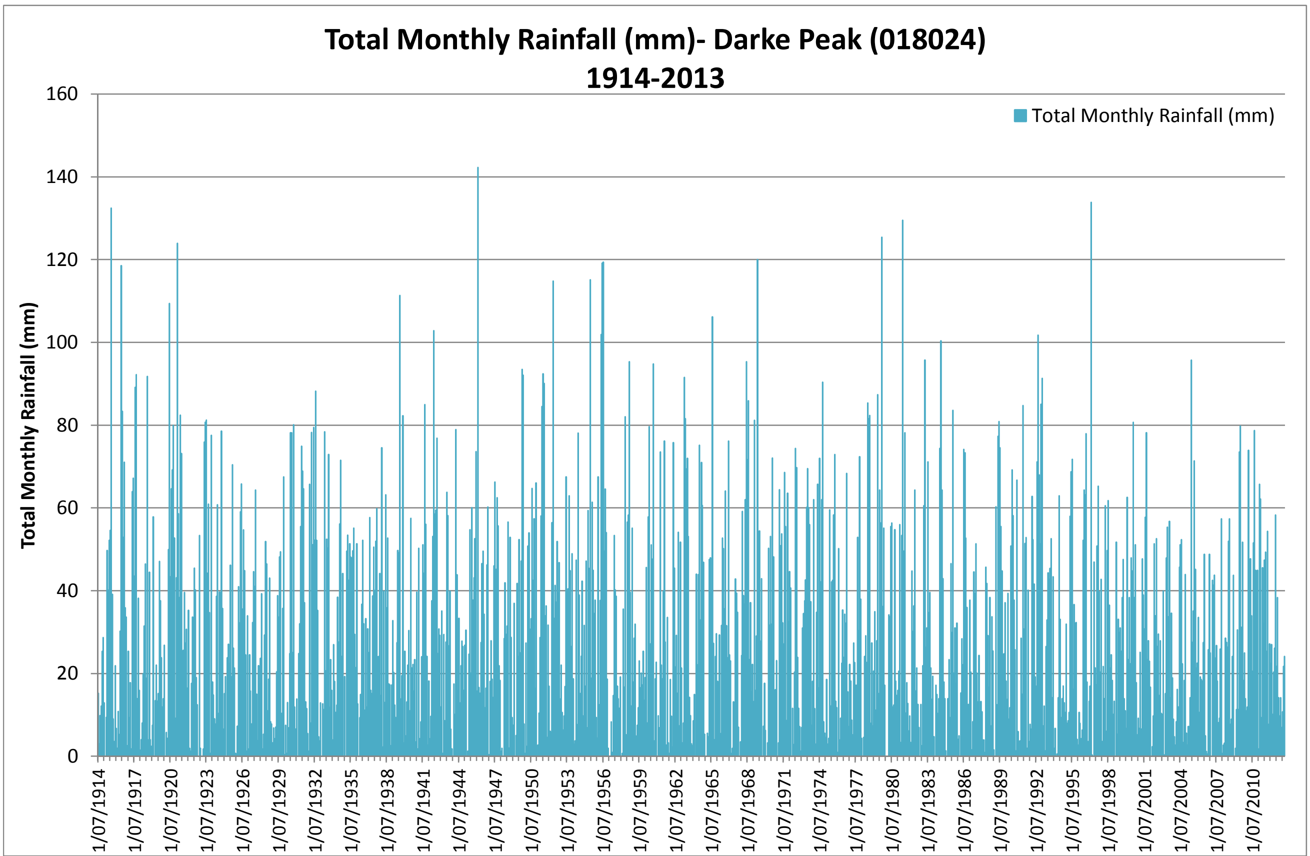


Figure D10: Total monthly rainfall at Darke Peak station (018024).

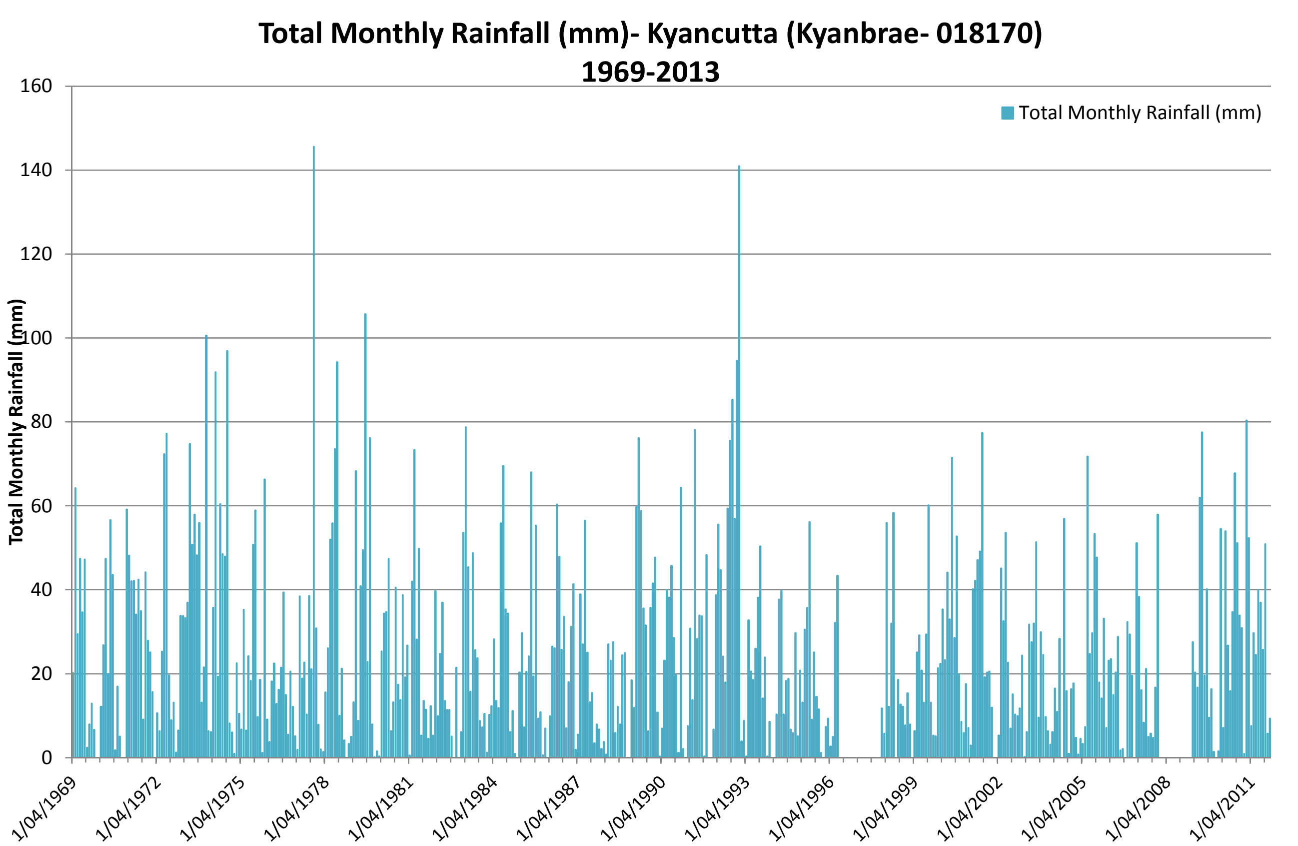


Figure D11: Total monthly rainfall at Kyancutta (Kyanbrae) station (018170).

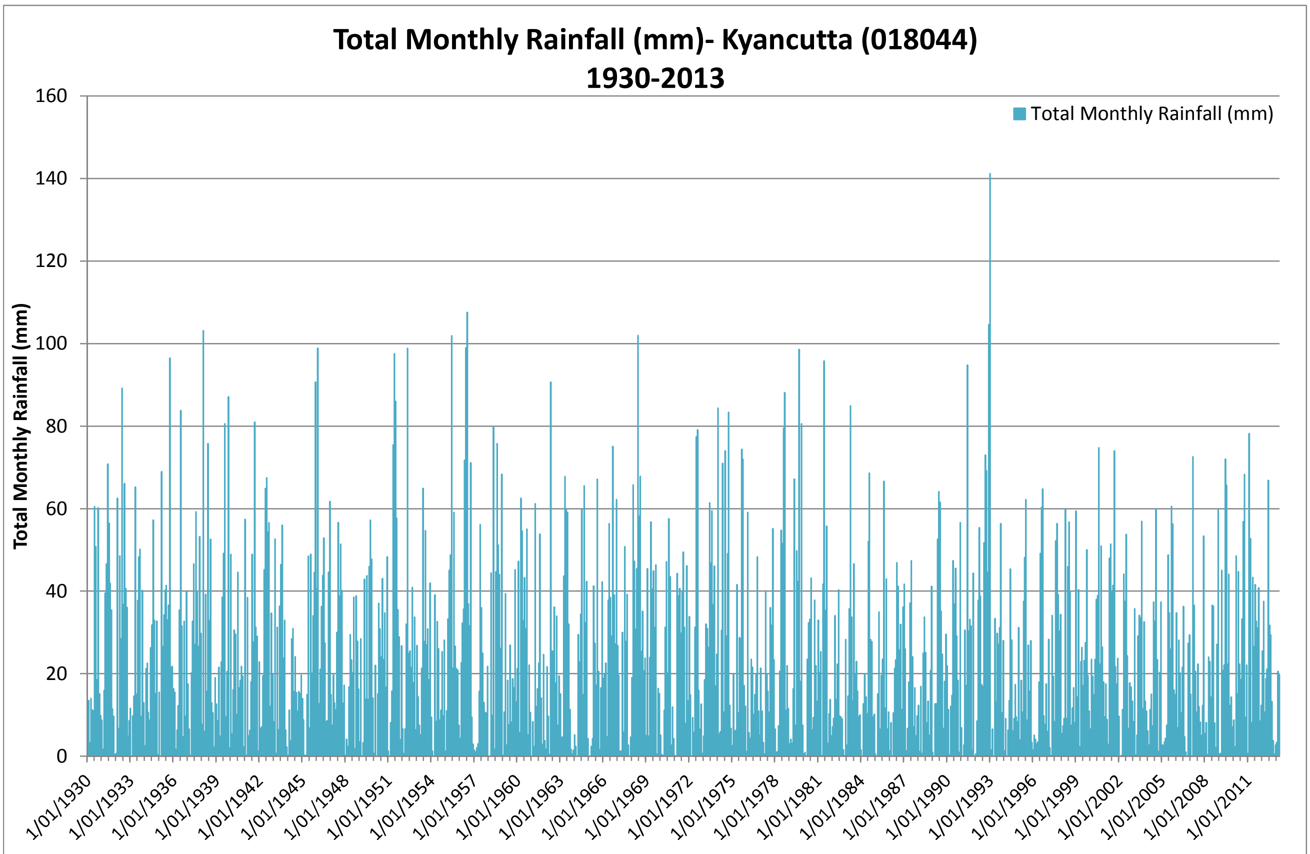


Figure D12: Total monthly rainfall at Kyancutta station (018044).

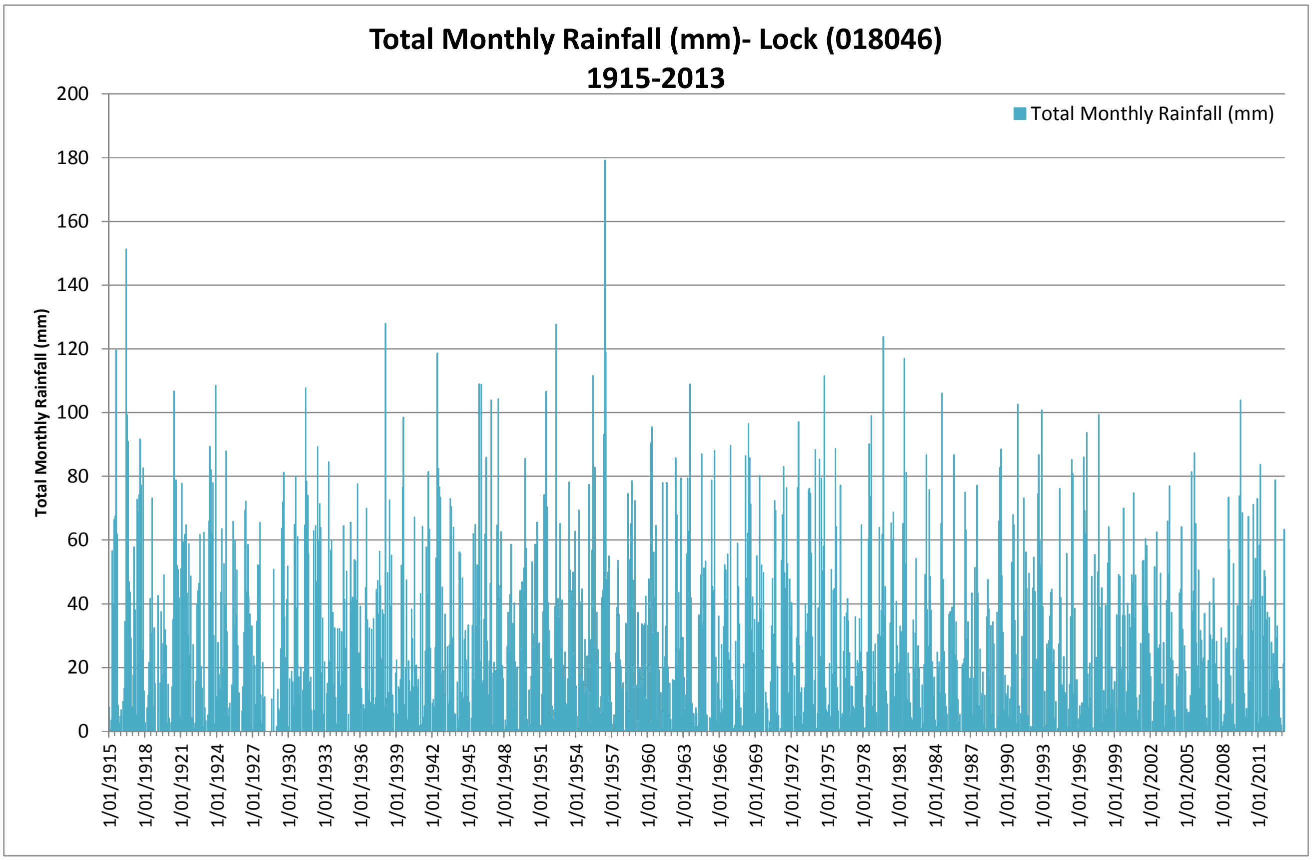


Figure D13: Total monthly rainfall at Lock station (018046).

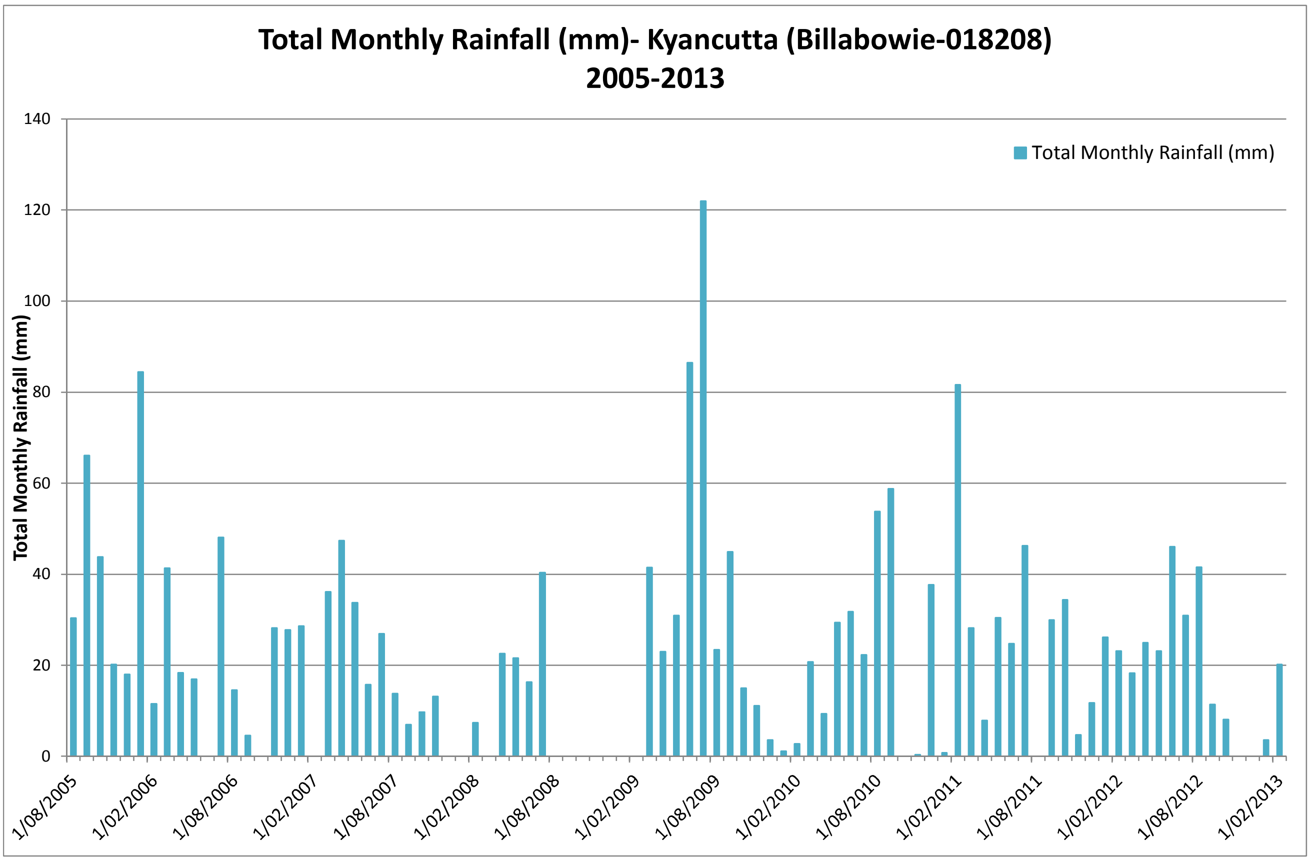


Figure D14: Total monthly rainfall at Kyancutta (Billabowie) station (018208).

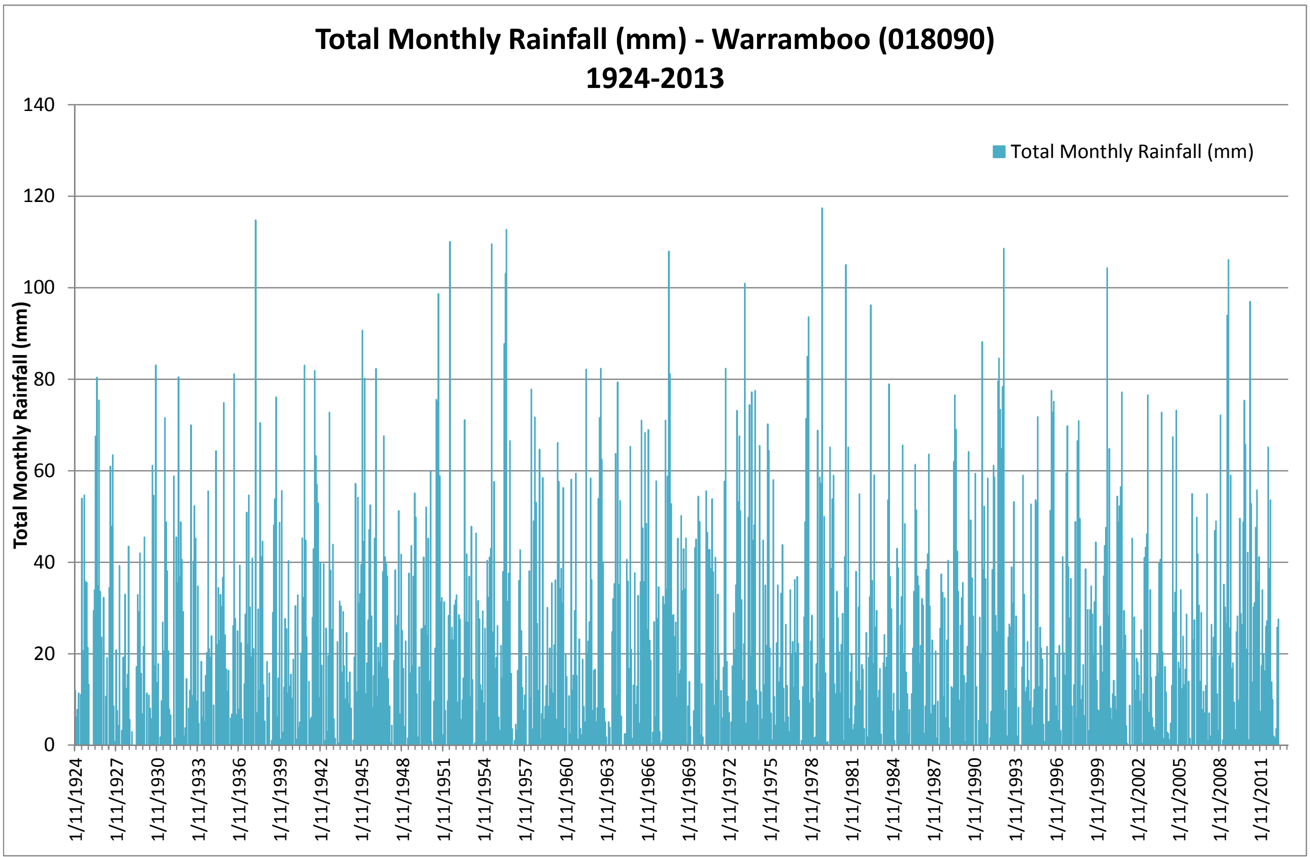


Figure D15: Total monthly rainfall at Warramboo station (018090).

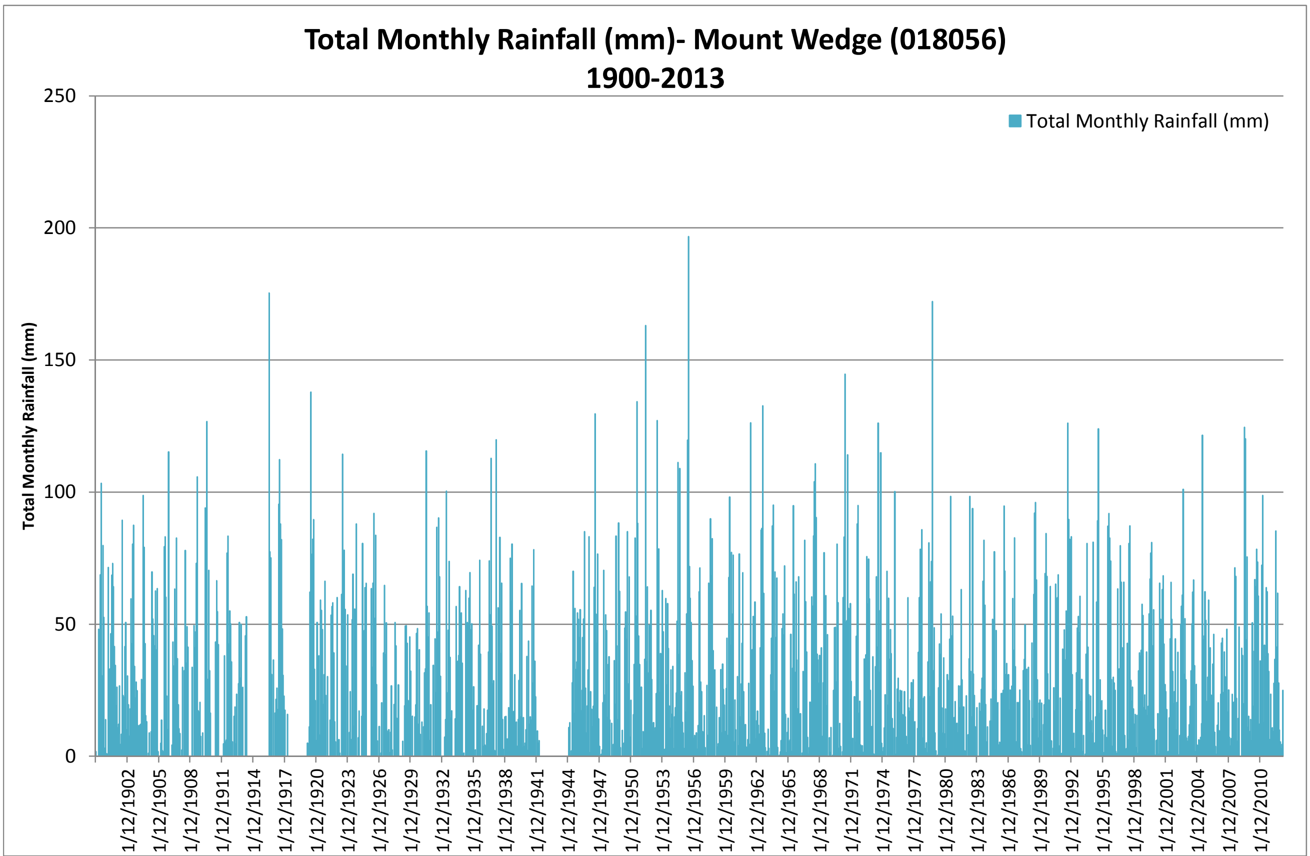


Figure D16: Total monthly rainfall at Mount Wedge station (018056).

Table D1: GENERATED PROJECT SITE MONTHLY RAINFALL (mm)

WARRAMBOO STATION 018090

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1924											12	6.1	
1925	7.8	11.4	0	11.1	54	20.7	54.7	35.9	35.6	21.4	13.3	0	265.9
1926	0	0	29.4	34	67.5	80.4	34.9	75.5	33.6	23.6	0	32.3	411.2
1927	0	10.7	19.1	0	34.5	61	47.8	63.5	8.6	0.8	20.8	7.6	274.4
1928	4.3	39.3	0	3.3	19.2	19.3	33	12.4	15.5	43.5	5.6	0	195.4
1929	3	0	0	0	17.2	32.9	29.2	42	15.7	6.9	21.6	45.5	214
1930	0	11.4	0	10.9	8.1	5.8	61.2	54.6	17.3	83.1	13.7	17.8	283.9
1931	0	1.8	9.7	26.9	20.6	71.6	48.8	38.1	20.6	7.9	6.6	0	252.6
1932	0	58.9	1.5	45.5	35.6	80.5	36.8	48.8	40.6	29.2	2	3.8	383.2
1933	14.5	0	8.1	12	70	10.8	40.2	52.4	45.2	9.6	34.8	4.8	302.4
1934	0	18.3	6.1	11.6	5.1	15.2	20.3	55.6	21.1	19.2	23.9	0	196.4
1935	8.8	0	64.3	22	34.5	22.9	32.9	30.3	36.7	74.9	24.1	16.6	368
1936	11.7	16.3	0	5.9	6.8	26.1	81.2	27.7	6.7	25	7.9	39.4	254.7
1937	22.4	5.8	0	13.4	28.6	50.9	22.1	54.7	30.2	19.3	40.9	21.1	309.4
1938	0	114.8	7.1	29.8	12	70.5	41.2	44.6	13.2	5.3	0	18.3	356.8
1939	10.4	15.8	0	1	29	48.1	53.8	76.1	6.1	14.7	48.7	1.3	305
1940	55.7	2.8	12.7	27.7	25.4	11.4	40.3	12.9	15.5	10.2	18.8	0	233.4
1941	30.5	1.3	32.8	3.8	5.1	20.1	45.3	32.3	83.1	44.8	23.7	0	322.8
1942	14	5.6	6.1	27.9	42.9	81.9	63.3	57.1	52.9	10.4	39.9	17.5	419.5
1943	0	39.6	1	25.6	3	19.6	72.8	38.2	25.3	43.9	5.8	1.5	276.3
1944	0	22.6	0.5	31.5	30.4	16	29.2	17.3	10.1	24.6	13.7	9.1	205
1945	16	8.1	0	1.1	19.3	57.2	11.6	54.2	31	33.1	39.5	90.7	361.8
1946	44.5	80.2	11.2	18	27.4	47.1	52.5	28.2	8.2	15.2	45.2	82.3	460
1947	10.7	21.4	18.1	22.4	17	38	67.6	41.2	39.6	37	14.5	8.6	336.1
1948	0.5	4.4	0	18.5	38.3	26.2	28.3	51.2	6.8	41.7	25.1	16.8	257.8
1949	4.1	22.8	0	1.6	37.6	15.8	43.6	17.3	36.9	55.1	49.8	11.2	295.8
1950	1.8	17.1	0	25.4	25.5	41.1	26.1	52.1	23.9	45.2	14	59.9	332.1
1951	0.8	0	9.6	21.2	75.6	75.2	98.7	58.9	31.3	32.3	2.3	31.3	437.2
1952	7.6	0	9.7	28.4	110.1	23	25.8	23	30.6	31.7	32.8	9.4	332.1
1953	28.5	27.5	5.6	9.9	14.7	71.1	26.9	41.8	26.9	36.9	10.5	47.8	348.1
1954	14.3	0	0.5	46.3	7.4	31.6	27.6	13.2	12	29.3	9.2	25.6	217
1955	0.8	40.4	32.3	41.1	43	109.6	24.7	57.6	16.8	19.2	26.1	6.1	417.7
1956	3.3	21.8	14.7	38	87.8	103.1	112.7	31.4	37.6	66.6	15.7	3.6	536.3
1957	0	1	4.6	3.3	16.3	36	42.7	25	12.6	7.6	10.9	19.4	179.4
1958	0	0	38.1	10.4	77.8	3.5	49	71.7	53.1	26.6	11.9	64.7	406.8
1959	1.3	6.9	58.5	5.6	8.5	13	30.1	8.5	21.2	12.2	35.5	11.4	212.7
1960	21.9	36.1	5.6	66.1	57.6	34.3	38.7	31	56.3	3.6	19.9	15	386.1
1961	0	10.8	2.5	58.1	12.1	15.3	29.4	59.4	15.3	1.3	23.2	3.7	231.1
1962	2.3	18.8	8.4	5.1	82.2	20.1	22.8	27	58.4	36.2	7.6	16.3	305.2
1963	16.6	5.1	8.2	53.9	71.6	82.4	62.5	40.1	8	5.1	1.8	0	355.3
1964	5.1	3.9	0	24.8	32	35.3	63.8	10.8	79.4	35.1	53.5	6.3	350
1965	0	0	2.5	2.6	40.6	35.9	16.8	65.3	21	1.5	13.1	37.7	237
1966	8.9	12.9	32.7	4.8	35.7	71	47.5	35.7	68.3	48.4	25.3	68.9	460.1
1967	22.9	18.6	0.3	2.8	27	6.2	57.8	27.7	34.6	3	0.5	1.1	202.5
1968	32.5	30.7	71	34.1	58.8	108	81.2	52.8	28.3	28.5	23.7	26.9	576.5
1969	10.4	45.2	15.6	16.4	50.2	33.8	42.9	34.1	45.3	0.3	8.6	13.9	316.7
1970	4.1	0	0	7.5	43.2	45	19.7	54.4	48.9	2.3	13.5	1.8	240.4
1971	0	0	55.6	46.5	42.7	42.8	38.6	53.8	37.9	8.7	41.1	14.2	381.9
1972	33	19.9	0	11.9	5.9	17	57.7	82.4	18.3	10.7	7.1	0	263.9
1973	5.1	17.3	28.9	20.9	35	73.1	53.2	67.6	51.2	31.8	14.2	22.2	420.5
1974	101	4.8	9.6	49.8	74.4	19.4	77.2	44.8	48.2	77.6	12	8.8	527.6
1975	1	65.5	11.6	5.6	44.8	13.2	35	21.8	70.2	64.4	21.2	7	361.3
1976	1.2	58	10.6	4.4	22.4	35	13.8	17	33.2	43.8	12.4	5	256.8
1977	26.4	13	6.2	3	34	20	22.6	12.6	36.2	20.2	36.8	22.2	253.2
1978	9.8	0	1	12.8	28	48.8	71.4	85	93.6	9.2	22.8	28.4	410.8
1979	10.2	1.6	1.8	17.8	68.8	11.6	58.6	57.2	117.4	23.2	50	15.8	434
1980	0.6	0.8	0	65.2	38.6	53.8	59	13.4	11.2	33.6	27.8	20.4	324.4
1981	11.4	22	28.8	1	41.2	105	34.4	65.2	5.8	16	19.8	3.4	354
1982	4.6	8.6	38	14	30.2	55	12	17.6	16.6	3.6	0	24.6	224.8
1983	1.8	19.2	32.4	96.2	36	17.8	59.1	25.8	29.4	10.4	12	16.8	356.9
1984	2.4	0	18	24.2	17	19.2	53.6	79	36.8	29.8	7.4	11.4	298.8
1985	1	0	43	38.8	7.6	26.2	32.4	65.6	19.8	48.4	16	11.2	310
1986	2.4	7.8	0	11.2	21.2	33.6	61.4	51.4	37	34.9	17.8	21.8	300.5
1987	32	30.6	2.6	8.6	38.4	41.8	63.6	30.4	6.8	23	8.6	8.8	295.2
1988	20.6	1.6	9.6	0.2	25.6	37.4	33.4	10.6	32.2	6	23	40.4	240.6
1989	3.8	0	12.8	12.4	62	76.6	69	42.4	33.6	9.8	26.2	32.2	380.8
1990	35.6	15.2	0.8	13.6	21.6	64.2	40.2	49.2	36.6	28.2	0	59.4	364.6
1991	12.8	0	5.4	27.9	20	88.2	38.4	52.2	36.4	4.6	58.4	0	344.3
1992	1.6	7.4	38.4	61.2	58.6	28.4	24.8	79.6	84.6	73.4	64.8	78.4	601.2
1993	108.6	7.6	12	2	23.6	26.5	25.8	38.9	31.1	53.2	12.4	28.2	369.9
1994	2	8.3	0	0	17.1	59	33	11.6	12.6	22.6	14.2	9.6	190
1995	52.7	4.4	8.2	12.2	53.6	53.1	71.8	12.8	25.8	21.2	18.8	4.6	339.2
1996	0.8	12.2	21.6	5.1	5.2	51.3	77.6	72.8	75.2	14.8	8.6	20	365.2
1997	5.3	21.8	3.2	0	41.2	20.2	15.3	59.5	69.8	39	27.8	36.4	339.5
1998	8.6	0	13.2	48.9	5.9	66.6	70.9	49.6	10	13	17.6	6.4	310.7
1999	38.5		29.6	3.2	29.6	34.8	28.6	19.6	31.3	44.4	14.2	7.7	
2000	7.5	26	21.8	16	37	43.6	47.6	104.3	28.2	64.8	8.1	5.6	410.5
2001	11.2	14.2	10.7	7.7	54.4	48.8	52.3	56.5	77.2	20.8	29.4	24	407.2
2002	4.2	0.4	0	8.7		45.2		28	12	19	18.2	15.3	
2003	9.6	25.2	0.4	11.2	41	43.3	46.2	76.6	7.2	34	14.8	6	315.5
2004	4	3.2	15	20	15.8	39.8	40.6	72.8	20.4	1.4	17.2	11.6	261.8
2005	2.8	2.6	1.2	4.8	13	67.4	29	33.4	73.2		18.2	16.8	
2006	34	12.3	23.8	13.2	16.6	28.6		14	1.5	0	55	23	
2007	27.4	0	49.8	41.8	30.6	14	29	7.8	11.8	7	13	55	287.2
2008	1	7	2	26.4	19.2	23.6	46.9	49	11.2	3.3	19.6	72.2	281.4
2009	0	1.2	35.2	30.2	26.6	94	106.2	25.6	59	16.8	18	9.4	422.2
2010	3.4	24.8	28.2	9.8	49.6	28.8	26.4	48.8	75.4	65.8	21	42.2	424.2
2011	1.2	97	52.8	13.8	30.2	31.2	47.6	55.8	35.8	41.2	7.4	17.4	431.4
2012	34	19.8	16.2	26	27.2	65.2	38.6	53.6	13.8	10	2	1.6	308
2013	3.6	25.8	27.6	25.8	35	57.6	68.2						

KYANCUTTA (KYANBRAE) STATION 018170

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1924													
1925													
1926													
1927													
1928													
1929													
1930													
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1965													
1966													
1967													
1968													
1969				20.2	64.3	29.5	47.5	34.7	47.3	2.5	8	13	
1970	6.7	0	0	12.2	26.9	47.5	20	56.7	43.7	1.8	17	5.1	237.6
1971	0	0	59.2	48.2	42.1	42.2	34.2	42.5	35	9.2	44.3	27.9	384.8
1972	25.2	15.7	0	10.7	6.4	25.3	72.4	77.3	19.7	9	13.2	1.3	276.2
1973	6.6	33.9	33.8	33.4	37	74.9	50.8	58	48.3	56	13.2	21.6	467.5
1974	100.6	6.4	6.2	35.8	91.9	19.4	60.5	48.6	48	97	8.2	6.1	528.7
1975	1	22.6	10.5	6.8	35.3	6.6	24.3	18.4	50.8	59	9.8	18.6	263.7
1976	1.2	66.4	9.2	3.8	18.2	22.5	12.9	16.3	21.5	39.4	15	5.6	232
1977	20.6	12.2	5.2	2	38.5	18.9	22.8	10.4	38.6	21.1	145.6	30.9	366.8
1978	7.9	2.1	1.4	15.6	26.2	52	55.9	73.6	94.3	10.1	21.3	4.2	364.6
1979	0	3.4	5	13.3	68.4	8.8	41	49.5	105.7	22.9	76.2	8	402.2
1980	0.2	1.6	0.4	25.4	34.4	34.8	47.5	6.4	13.3	40.6	17.5	13.8	235.9
1981	38.8	19.2	26.8	0.6	42	73.4	28.2	49.8	5.4	13.6	11.5	4.6	313.9
1982	12.4	5.3	39.7	10	24.8	37	13.6	11.4	11.4	5.1	0	21.5	192.2
1983	0	6.2	53.6	78.8	45.5	15.8	48.8	25.7	23.8	8.8	7.3	10.5	324.8
1984	1.3	10.3	12.4	28.3	13.6	11.9	55.9	69.6	35.4	34.4	6.2	11.2	290.5
1985	1	0	20.4	29.8	7.3	20.5	24.3	68.1	19.5	55.4	9.4	10.9	266.6
1986	0.7	7	0	10	26.6	26.2	60.4	47.9	25.8	33.7	7.1	18.1	263.5
1987	31.3	41.4	2	5.6	39	27.1	56.5	25.1	13.3	15.5	3.5	8	268.3
1988	6.8	2.2	3.8	0.8	27.1	23.2	27.6	6	12.2	8	24.5	25	167.2
1989	0	0	18.5	12	59.8	76.2	58.9	35.6	31.6	6.4	35.8	41.6	376.4
1990	47.8	10.8	0.4	7	23.2	40	38.2	45.8	28.6	19.8	1.2	64.4	327.2
1991	2.2	0	7.6	30.8	13.8	78.2	28.4	34	33.8	0.4	48.4	0	277.6
1992	0	6.8	38.8	55.6	44.8	24.2	18	59.4	75.6	85.4	57	94.6	560.2
1993	141	4	8.8	0.4	32.8	20.6	18.6	26	38.2	50.4	14.2	24	379
1994	0.4	8.6	0	0	10.4	37.8	39.8	10.4	18.4	18.8	6.8	6	157.4
1995	29.8	5.2	20.8	13.2	30.6	35.8	56.2	9.2	25.2	14.6	11.6	1.2	253.4
1996	0	7.4	9.4	2.8	5	32.2	43.4						
1997													
1998	0	11.8	5.8	56	12.2	32	58.4		18.6	12.8	12.2	7.8	
1999	15.4	8		6.4	25.2	29.2	20.8	13.2	29.4	60.2	13.2	5.4	
2000	5.2	21.4	22.4	35.4	23.4	44.2	33	71.6	28.6	52.8	20	8.6	366.6
2001	6	17.6	7.2	3	40.2	42.2	47.2	49.2	77.4	19.2	20.4	20.6	350.2
2002	12	0	0	5.4	45.2	32.6	53.6	22.8	7	15.2	10.4	10	214.2
2003	11.8	24.4	0.2	6.2	31.8	27.6	32	51.4	9.6	30	24.6	9.8	259.4
2004	6.4	3.2	6.2	16.6	11	28.4		57	16	1	16.4	17.8	
2005	4.8	0.8	4.6	3.4	7.4	71.8	24.8	29.8	53.4	47.8	18	14.2	280.8
2006	33.2	7.2	23.2	23.6	15	20.4	28.8	1.8	2.2	0	32.4	29.4	217.2
2007	19.6	0	51.2	38.4	16.2	8.4	21.2	5	5.8	4.8	16.8	58	245.4
2008													
2009	0	0	27.6	20.4	16.8	62	77.6	19.6	40.2	9.6	16.4	1.4	291.6
2010		1.6	54.6	7.2	54	26.8	16	34.8	67.8	51.2	34	31	
2011	1	80.4	52.4	7.6	29.8	24.6	40	37	25.8	51	5.8	9.4	364.8
2012	34.8	40	13.2	14.2	22.8	62.8	21.2	29.6	11	7	2.8	8.2	267.6
2013	2	26	49.2	16.2	14.8	54.8	52						

KOONGAWA (RETAWON) STATION 018101

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1924													
1925													
1926													
1927													
1928													
1929													
1930													
1931													
1932													
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1946													
1947													
1948													
1949													
1950													
1951								34.4	31.4	33.7	8.7	24.1	
1952	10.9	1.6	16.5	40.4	125.3	31.3	30.9	21.4	40.6	28.2	47.7	5.7	400.5
1953	28	7.7	4.3	7.1	11.8	67	33.2	41.6	30.6	40.8	20.7	55	347.8
1954				42.4	5.3	47.5	28.7	8.9	19.6	29.1	16.6	28.9	
1955	0	14.2	65.3	39	50.2	110	25.5	43.7	22.1	21.8	19.5	5.6	416.9
1956	8.9	23.6	38.3	54.5	89.5	89.3	139.5	29.9	54.6	65.5	9	5.1	607.7
1957	2.5	0	7.9	1.3	5.3	24.5	27.5	35.1	6.3	6.6	7.6	25.9	150.5
1958	0	0	39.4	11.7	83.1	4.8	38	57.5	72.1	10.1	10.2	53.8	380.7
1959	4.3	14.2	70.4	7.9	9.9	9.7	31.5	9.7	16.5	4.1	33.5	12.2	223.9
1960	24.9	34	7.6	40.8	67	37.5	51.4	36.9	85.8	5.6	19.8	22.4	433.7
1961	0	4.8	2.8	83.6	9.4	11.4	29.7	64.3	21.3	0.5	3.6	0	231.4
1962	0	15.2	7.9	0	96.7	17.1	14.3	37.6	12.7	34.7	0	0	236.2
1963	15.2	7.6	0	81.1	78.3	52.3	65.8	34.1	8.1	9.1	2.1	0.8	354.5
1964	5.3	3.3	0.8	38.8	28	39.1	58.3	20.3	74.1	56	40	8.1	372.1
1965	0	0	3	5.8	49.1	30.4	25.3	101.6	23.6	3.6	9.9	28.3	280.6
1966	13.9	27.5	26.7	3.9	28.8	81	55	31.5	47.2	20.4	30.2	58.2	424.3
1967	23.9	23.4	0	2	31.8	6.4	41.9	27.5	34.6	2.3	0	2.8	196.6
1968	21.9	71.4	30.3	40.5	62	116.4	83.7	69.2	24.5	32.5	21.8	19.5	593.7
1969	2.5	73.9	11.4	29.3	69.2	32.1	55.9	33.6	48	1	3	15.7	375.6
1970		0.3	0.3	14.5	32.5	45.7	19.6	56.1	55.4	0	15.3	12.4	
1971	0	0	46.7	53.3	44.1	47.3	35	54.2	39.5	9.2	49.5	17	395.8
1972	83.5	14.6	0	12.4	7.6	22.4	67.5	82.8	16	10.5	5.1	2.3	324.7
1973	4.5	35.6	36.1	28.9	32.3	71.7	55.4	53.7	61.4	61.5	12.5	18	471.6
1974	119.8	5.6	11.6	36	107.6	18.2	62	35.5	54	93.9	5.2	7.2	556.6
1975	1.5	19.8	10.2	9.2	53	5.2	30.4	27	75.4	79.7	16.2	20.2	347.8
1976	0	24.6	4	6.4	21	28	13.9	20.9	25.6	57	13.8	2.8	218
1977	18.6	8.8	3.8	3	38.6	23.3	20	16	31.6	16.6	110.2	31.6	322.1
1978	13.8	3.6	6.8	10.8	29.8	73	63.7	69	83.4	9	25.8	4.4	393.1
1979	0	34.6	3.6	14.2	80.8	10.2	42.6	55	121	16.6	66.2	7.2	452
1980	0	2.2	0	26.4	38.6	60.8	62.6	4.8	14.6	49.6	17.2	11.4	288.2
1981	37.4	18.2	20.2	0.6	45.4	88.6	28.4	55.2	6.6	15.8	15	5.4	336.8
1982	10.4	2	44.6	14.8	23.2	39.4	12.2	14.8	13.4	2.4	0	18.2	195.4
1983	1.4	7.4	63.8	90.6	75.8	22	51.4	30	22.6	24.4	7.2	11.8	408.4
1984	2.2	0	14.9	27.6	16	16.6	50.8	69.6	38.2	31.6	8	10.8	286.3
1985	2.4	0	16	22.6	4.8	24	29.8	65.6	19.4	51.4	11.4	13.4	260.8
1986	2	6	3.1	10.4	23.4	33.2	52.8	54.2	38.4	40.2	9.8	11.2	284.7
1987	37.4	28.8	0.2	7	60	25.2	59.8	23.4	8.4	16.2	6.4	11.8	284.6
1988	9	2.2	11.2	0.2	32.6	36.6	20.3	14.4	26.6	8.4	29	28.6	219.1
1989	0.6	0	19.2	4.6	61.8	86.4	69.6	39	29.4	6.6	16.7	27.4	361.3
1990	32.6	12.2	0	9.8	20	53.2	48.4	61.8	30	24.4	0	93.2	385.6
1991	5.6	0	12.6	27.2	13.8	85.2	30.4	39	40	1.2	44.8	0	299.8
1992	0.4	5.6	42.8	31.8	52.6	32.6	21.2	68.8	86	56.7	41.2	103.6	543.3
1993	123.4	5.6	9	0	35.8	29.4	39.4	30.4	56.4	44.6	12	38.4	424.4
1994	0	12.8	0	0	15.2	57.4	36.2	6.8	21	19.4	9.4	7.8	186
1995	26.6	5.4	11.6	16	32.4	55	71.4	13.2	33.8	17.8	39.2	3.8	326.2
1996	1.4	11.8	6.6	5.6	3.4	48.2	70.2	75.6	62.8	19	7.8	15.8	328.2
1997	6.6	61	0.4	0	42.6	14.8	10.8	52	60.8	36.2	25.6	27.4	338.2
1998	8.2	15.6	9.4	65.2	7.4	42.6	66.6	34.6	22.6	13.4	17.2	8.4	311.2
1999	32.8	0	55.2	5.8	38.2	38.8	17.6	25	27.6	53.2	14	9	317.2
2000	4.6	26.2	26.8	47	28	48	40.2	93.8	37.2	49.4	17.6	8.6	427.4
2001	10.6	21	17.8	3.8	42	53.8	40.2	56	68.6	29	35.8	23.4	402
2002	13	0	0.4	8.2	59	40.2	52.4	32.4	11.4	18	16.8	13.8	265.6
2003	12.8	27.4	0	6		37.2	41.4	59.2	14.8	36.2	26.2	9	
2004	6.4	4.4	5.2	14.6	11.2	36.4	53.4	60.4	23.2	2.8	20.6		
2005	5.2	0.8	5.2	6.2	8.8	76.6	33.4	36.8	58.4	49.6	19.6	16.4	317
2006	22.6	9.2	18.8	19.2	17.2	27.8	37	6	2.8	0.4	27.4	24.8	213.2
2007	36.4	0	39.8	47.4	27.4	13.4	24	8.2	8.8	11	20	71	307.4
2008	2.2	6.2	1.2	17.6	30.8		45.4	37.2	7.4	1.4	21.8	54.8	
2009	4	1.4	29.6	23.2	10.2	85.4	96.8	24.2	55	20	16.4	6.8	373
2010	10.9	13	57.4	9		27.6	22.8	40.2	77.6	46	7.6	18.8	
2011	0	74.2	60.2	13	32	29.3	39	57.4	28.3	46	8		
2012	16.6		12.8	17.5	18.5	65.1	24.9	39.5					
2013													

PROJECT SITE DESIGN RAINFALL

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1924											12.0	6.1	
1925	7.8	11.4	0.0	11.1	54.0	20.7	54.7	35.9	35.6	21.4	13.3	0.0	265.9
1926	0.0	0.0	29.4	34.0	67.5	80.4	34.9	75.5	33.6	23.6	0.0	32.3	411.2
1927	0.0	10.7	19.1	0.0	34.5	61.0	47.8	63.5	8.6	0.8	20.8	7.6	274.4
1928	4.3	39.3	0.0	3.3	19.2	19.3	33.0	12.4	15.5	43.5	5.6	0.0	195.4
1929	3.0	0.0	0.0	0.0	17.2	32.9	29.2	42.0	15.7	6.9	21.6	45.5	214.0
1930	0.0	11.4	0.0	10.9	8.1	5.8	61.2	54.6	17.3	83.1	13.7	17.8	283.9
1931	0.0	1.8	9.7	26.9	20.6	71.6	48.8	38.1	20.6	7.9	6.6	0.0	252.6
1932	0.0	58.9	1.5	45.5	35.6	80.5	36.8	48.8	40.6	29.2	2.0	3.8	383.2
1933	14.5	0.0	8.1	12.0	70.0	10.8	40.2	52.4	45.2	9.6	34.8	4.8	302.4
1934	0.0	18.3	6.1	11.6	5.1	15.2	20.3	55.6	21.1	19.2	23.9	0.0	196.4
1935	8.8	0.0	64.3	22.0	34.5	22.9	32.9	30.3	36.7	74.9	24.1	16.6	368.0
1936	11.7	16.3	0.0	5.9	6.8	26.1	81.2	27.7	6.7	25.0	7.9	39.4	254.7
1937	22.4	5.8	0.0	13.4	28.6	50.9	22.1	54.7	30.2	19.3	40.9	21.1	309.4
1938	0.0	114.8	7.1	29.8	12.0	70.5	41.2	44.6	13.2	5.3	0.0	18.3	356.8
1939	10.4	15.8	0.0	1.0	29.0	48.1	53.8	76.1	6.1	14.7	48.7	1.3	305.0
1940	55.7	2.8	12.7	27.7	25.4	11.4	40.3	12.9	15.5	10.2	18.8	0.0	233.4
1941	30.5	1.3	32.8	3.8	5.1	20.1	45.3	32.3	83.1	44.8	23.7	0.0	322.8
1942	14.0	5.6	6.1	27.9	42.9	81.9	63.3	57.1	52.9	10.4	39.9	17.5	419.5
1943	0.0	39.6	1.0	25.6	3.0	19.6	72.8	38.2	25.3	43.9	5.8	1.5	276.3
1944	0.0	22.6	0.5	31.5	30.4	16.0	29.2	17.3	10.1	24.6	13.7	9.1	205.0
1945	16.0	8.1	0.0	1.1	19.3	57.2	11.6	54.2	31.0	33.1	39.5	90.7	361.8
1946	44.5	80.2	11.2	18.0	27.4	47.1	52.5	28.2	8.2	15.2	45.2	82.3	460.0
1947	10.7	21.4	18.1	22.4	17.0	38.0	67.6	41.2	39.6	37.0	14.5	8.6	336.1
1948	0.5	4.4	0.0	18.5	38.3	26.2	28.3	51.2	6.8	41.7	25.1	16.8	257.8
1949	4.1	22.8	0.0	1.6	37.6	15.8	43.6	17.3	36.9	55.1	49.8	11.2	295.8
1950	1.8	17.1	0.0	25.4	25.5	41.1	26.1	52.1	23.9	45.2	14.0	59.9	332.1
1951	0.8	0.0	9.6	21.2	75.6	75.2	98.7	52.0	31.3	32.7	4.1	29.3	430.5
1952	8.5	0.4	11.6	31.8	114.4	25.3	27.2	22.6	33.4	30.7	37.0	8.4	351.3
1953	28.4	22.0	5.2	9.1	13.9	70.0	28.7	41.7	27.9	38.0	13.4	49.8	348.0
1954	14.3	0.0	0.5	45.2	6.8	36.1	27.9	12.0	14.1	29.2	11.3	26.5	223.9
1955	0.6	33.1	41.5	40.5	45.0	109.7	24.9	53.7	18.3	19.9	24.3	6.0	417.5
1956	4.9	22.3	21.3	42.6	88.3	99.2	120.2	31.0	42.4	66.3	13.8	4.0	556.3
1957	0.7	0.7	5.5	2.7	13.2	32.8	38.4	27.8	10.8	7.3	10.0	21.2	171.3
1958	0.0	0.0	38.5	10.8	79.3	3.9	45.9	67.7	58.4	22.0	11.4	61.6	399.5
1959	2.1	8.9	61.8	6.2	8.9	12.1	30.5	8.8	19.9	9.9	34.9	11.6	215.8
1960	22.7	35.5	6.2	59.0	60.2	35.2	42.3	32.7	64.6	4.2	19.9	17.1	399.4
1961	0.0	9.1	2.6	65.2	11.3	14.2	29.5	60.8	17.0	1.1	17.7	2.7	231.2
1962	1.7	17.8	8.3	3.7	86.3	19.3	20.4	30.0	45.6	35.8	5.5	11.7	285.9
1963	16.2	5.8	5.9	61.5	73.5	74.0	63.4	38.4	8.0	6.2	1.9	0.2	355.1
1964	5.2	3.7	0.2	28.7	30.9	36.4	62.3	13.5	77.9	41.0	49.7	6.8	356.2
1965	0.0	0.0	2.6	3.5	43.0	34.4	19.2	75.5	21.7	2.1	12.2	35.1	249.2
1966	10.3	17.0	31.0	4.5	33.8	73.8	49.6	34.5	62.4	40.6	26.7	65.9	450.1
1967	23.2	19.9	0.2	2.6	28.3	6.3	53.3	27.6	34.6	2.8	0.4	1.6	200.8
1968	29.5	42.1	59.6	35.9	59.7	110.4	81.9	57.4	27.2	29.6	23.2	24.8	581.3
1969	8.2	53.2	14.4	20.1	57.1	32.6	46.7	34.1	46.3	0.9	7.2	14.2	334.9
1970	4.7	0.1	0.1	10.0	37.8	45.6	19.7	55.2	49.5	1.7	14.5	4.8	243.7
1971	0.0	0.0	54.2	48.4	42.9	43.7	37.0	51.9	37.7	8.9	43.6	17.3	385.6
1972	43.2	17.9	0.0	11.8	6.4	19.7	62.6	81.6	18.0	10.3	7.7	0.8	280.1
1973	5.2	24.5	31.4	25.0	34.7	73.1	53.3	62.7	53.0	43.0	13.6	21.1	440.7
1974	105.3	5.3	9.4	44.1	85.2	19.1	70.7	43.3	49.5	84.8	9.8	7.9	534.5
1975	1.1	47.3	11.1	6.6	45.0	10.2	32.0	22.4	67.9	66.9	18.0	12.1	340.6
1976	0.9	51.8	8.8	4.8	21.3	31.1	13.7	17.8	29.3	46.0	13.2	4.6	243.4
1977	23.6	11.9	5.5	2.8	35.9	20.6	22.0	13.0	35.6	19.5	73.3	25.9	289.5
1978	10.4	1.2	2.4	12.8	28.1	54.9	66.8	79.3	91.4	9.3	23.2	18.5	398.4
1979	6.0	9.5	2.8	16.2	71.5	10.8	51.8	55.3	116.1	21.6	58.4	12.4	432.4
1980	0.4	1.3	0.1	49.1	37.8	52.0	57.8	10.2	12.4	38.5	23.5	17.1	300.1
1981	22.3	20.6	26.5	0.8	42.3	95.5	31.9	60.1	5.9	15.5	17.2	4.1	342.8
1982	7.3	6.5	39.8	13.5	27.6	48.2	12.3	15.8	14.9	3.6	0.0	22.6	212.2
1983	1.4	14.1	43.4	91.8	46.9	18.4	55.5	26.7	26.8	13.3	10.1	14.5	363.0
1984	2.2	1.9	16.3	25.7	16.2	17.3	53.4	75.1	36.9	31.0	7.3	11.2	294.4
1985	1.3	0.0	32.7	33.5	6.9	24.7	30.3	66.1	19.7	50.4	13.8	11.7	290.9
1986	2.0	7.2	0.7	10.8	22.7	32.2	59.2	51.4	35.3	35.9	14.0	18.7	290.2
1987	33.1	32.1	1.9	7.7	43.5	35.3	61.4	27.8	8.3	20.1	7.2	9.3	287.9
1988	15.4	1.8	8.9	0.3	27.5	34.7	29.3	10.6	27.3	6.9	24.7	34.9	222.4
1989	2.4	0.0	15.3	10.5	61.6	78.8	67.3	40.4	32.3	8.5	25.7	32.8	375.5
1990	37.1	13.7	0.5	11.5	21.5	57.3	41.7	51.5	33.6	25.8	0.2	68.1	362.7
1991	9.2	0.0	7.5	28.3	17.5	85.7	34.8	45.9	36.8	3.1	53.5	0.0	322.1
1992	1.0	6.9	39.5	53.4	54.7	28.6	22.7	73.5	83.3	71.7	58.0	87.1	580.5
1993	117.8	6.5	10.7	1.3	28.1	26.1	27.6	34.6	38.2	50.7	12.6	29.8	384.1
1994	1.3	9.4	0.0	0.0	15.5	54.8	35.0	10.3	15.6	21.2	11.8	8.5	183.2
1995	42.6	4.8	11.3	13.3	44.6	50.4	68.9	12.2	27.5	19.2	22.2	3.8	320.8
1996	0.8	11.2	16.0	4.8	4.8	47.1	69.7	73.6	71.7	16.0	8.4	18.8	342.9
1997	5.7	32.8	2.4	0.0	41.6	18.7	14.0	57.4	67.3	38.2	27.2	33.9	339.1
1998	7.0	5.7	11.0	53.9	7.4	54.9	67.7	45.4	14.4	13.1	16.5	7.1	304.0
1999	33.0	3.5	36.8	4.4	30.8	34.7	24.7	19.7	30.1	49.3	14.0	7.6	288.5
2000	6.4	25.2	23.1	26.6	32.5	44.7	43.3	96.0	30.3	59.1	12.4	6.8	406.5
2001	10.1	16.4	11.7	6.0	49.0	48.8	48.6	55.1	75.3	22.4	29.3	23.3	395.7
2002	7.6	0.2	0.1	8.0	52.9	41.8	52.9	28.1	11.0	18.1	16.5	14.0	251.2
2003	10.7	25.6	0.3	9.1	38.9	39.1	42.5	68.1	9.4	33.8	19.2	7.4	304.0
2004	5.0	3.5	11.2	18.1	13.9	37.0	44.2	67.1	20.3	1.7	17.8	13.0	252.7
2005	3.7	1.9	2.7	4.9	11.0	70.3	29.3	33.5	66.2	48.8	18.5	16.2	307.1
2006	31.2	10.7	22.5	16.5	16.5	26.9	33.4	10.0	1.9	0.1	44.6	24.6	238.8
2007	28.1	0.0	47.8	42.5	27.3	12.9	26.4	7.4	10.0	7.5	15.3	59.2	284.3
2008	1.3	6.8	1.8	23.9	22.4	23.6	46.5	45.7	10.1	2.8	20.2	67.3	272.5
2009	0.9	1.0	32.5	26.8	21.1	86.3	98.9	24.2	54.7	16.2	17.3	7.4	387.4
2010	5.5	17.9	39.7	9.1	50.6	28.2	23.7	44.3	74.5	58.6	20.3	34.8	407.2
2011	0.9	88.8	54.4	12.5	30.5	29.6	44.3	52.8	32.3	44.1	7.3	15.6	412.9
2012	30.1	24.4	14.9	21.9	24.4	64.7	32.3	46.0	13.2	9.3	2.2	3.1	286.7
2013	3.2	25.8	32.6	23.6	30.4	57.0							

RPS

GENERATED PROJECT SITE MONTHLY RAINFALL (MM) TABLE D.1

Appendix E CEWB Model output

APPENDIX E: CEWB MODEL OUTPUT

PRE-MINING AVERAGE YEAR:

Medium Permeability	Por. (η)	15.00%		K=	1.20E-04	m/s		a =	5.696					
Entire Mine Site Catchment														
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**	
Drainage area (Ha)	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00		
Average monthly rainfall (mm)	12.66	15.95	14.57	19.91	34.53	41.87	44.22	42.10	33.38	26.51	19.93	19.89	**325.53**	**mm**
Potential evapotranspiration (mm)	180.00	135.00	120.00	75.00	45.00	45.00	45.00	60.00	75.00	120.00	150.00	165.00		
Effective evapotranspiration coefficients	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67		
Effective evapotranspiration (mm)	120.60	90.45	80.40	50.25	30.15	30.15	30.15	40.20	50.25	80.40	100.50	110.55	**814.05**	**mm**
Soil moisture content (%)	0.00%	0.00%	0.00%	0.00%	0.09%	0.23%	0.28%	0.04%	0.00%	0.00%	0.00%	0.00%		
Percolation (to aquafers) ratio	1.00	1.00	1.00	1.00	1.00	0.99	0.99	1.00	1.00	1.00	1.00	1.00		
Average rainfall (ML/month)	591	744	680	929	1611	1954	2063	1965	1558	1237	930	928	**15189**	**ML**
Effective evapotranspiration (ML/month)	5627	4220	3751	2345	1407	1407	1407	1876	2345	3751	4689	5158	**37984**	**ML**
Average Infiltration (ML/month)	0	0	0	0	204	547	656	89	0	0	0	0		
Percolation to aquifers (ML/month)	0.0	0.0	0.0	0.0	203.8	542.2	649.4	88.6	0.0	0.0	0.0	0.0	**1484**	**ML**
Balance (ML/month)	-5037	-3476	-3072	-1415	1	5	7	0	-787	-2515	-3759	-4230		
Impounded volume (ML)	**0.0**	**0.0**	**0.0**	**0.0**	**0.7**	**5.4**	**12.3**	**12.4**	**0.0**	**0.0**	**0.0**	**0.0**		

Low Permeability	Por. (η)	10.00%		K=	1.00E-06	m/s		a =	24.993					
Entire Mine Site Catchment														
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**	
Drainage area (Ha)	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00		
Average monthly rainfall (mm)	12.66	15.95	14.57	19.91	34.53	41.87	44.22	42.10	33.38	26.51	19.93	19.89	**325.53**	**mm**
Potential evapotranspiration (mm)	180.00	135.00	120.00	75.00	45.00	45.00	45.00	60.00	75.00	120.00	150.00	165.00		
Effective evapotranspiration coefficients	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67		
Effective evapotranspiration (mm)	120.60	90.45	80.40	50.25	30.15	30.15	30.15	40.20	50.25	80.40	100.50	110.55	**814.05**	**mm**
Soil moisture content (%)	0.00%	0.00%	0.00%	0.00%	0.09%	0.23%	0.28%	0.04%	0.00%	0.00%	0.00%	0.00%		
Percolation (to aquafers) ratio	1.00	1.00	1.00	1.00	0.99	0.97	0.96	0.99	1.00	1.00	1.00	1.00		
Average rainfall (ML/month)	326	411	375	513	890	1079	1139	1085	860	683	514	513	**8389**	**ML**
Effective evapotranspiration (ML/month)	3108	2331	2072	1295	777	777	777	1036	1295	2072	2590	2849	**20978**	**ML**
Percolation to aquifers (ML/month)	0.0	0.0	0.0	0.0	111.5	292.3	348.4	48.8	0.0	0.0	0.0	0.0	**801**	**ML**
Balance (ML/month)	-2782	-1920	-1697	-782	1	10	14	0	-435	-1389	-2076	-2336		
Impounded volume (ML)	**0.0**	**0.0**	**0.0**	**0.0**	**1.4**	**11.2**	**25.3**	**25.6**	**0.0**	**0.0**	**0.0**	**0.0**		

Very Low Permeability	Por. (η)	3.50%		K=	1.00E-08	m/s		a =	109.215					
Entire Mine Site Catchment														
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**	
Drainage area (Ha)	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00		
Average monthly rainfall (mm)	12.66	15.95	14.57	19.91	34.53	41.87	44.22	42.10	33.38	26.51	19.93	19.89	**325.53**	**mm**
Potential evapotranspiration (mm)	180.00	135.00	120.00	75.00	45.00	45.00	45.00	60.00	75.00	120.00	150.00	165.00		
Effective evapotranspiration coefficients	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67		
Effective evapotranspiration (mm)	120.60	90.45	80.40	50.25	30.15	30.15	30.15	40.20	50.25	80.40	100.50	110.55	**814.05**	**mm**
Soil moisture content (%)	0.00%	0.00%	0.00%	0.00%	0.09%	0.23%	0.28%	0.04%	0.00%	0.00%	0.00%	0.00%		
Percolation (to aquafers) ratio	1.00	1.00	1.00	1.00	0.97	0.91	0.89	0.98	1.00	1.00	1.00	1.00		
Average rainfall (ML/month)	76	96	88	120	208	252	266	253	201	159	120	120	**1956**	**ML**
Effective evapotranspiration (ML/month)	725	544	483	302	181	181	181	242	302	483	604	664	**4892**	**ML**
Percolation to aquifers (ML/month)	0.0	0.0	0.0	0.0	25.4	63.9	75.2	11.3	0.0	0.0	0.0	0.0	**176**	**ML**
Balance (ML/month)	-649	-448	-396	-182	1	7	9	0	-101	-324	-484	-545		
Impounded volume (ML)	**0.0**	**0.0**	**0.0**	**0.0**	**0.9**	**7.4**	**16.8**	**17.0**	**0.0**	**0.0**	**0.0**	**0.0**		

TOTAL Impounded Volume	**0.0**	**0.0**	**0.0**	**0.0**	**3.0**	**24.1**	**54.4**	**55.0**	**0.0**	**0.0**	**0.0**	**0.0**

PRE-MINING: 1957

Medium Permeability

Por. (n) 15.00% K= 1.20E-04 m/s

Entire Mine Site Catchment

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	
Drainage area (Ha)	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00		
1957 monthly rainfall (mm)	0.70	0.72	5.52	2.74	13.22	32.78	38.44	27.83	10.84	7.32	9.98	21.22	**171.31**	**mm**
Potential evapotranspiration (mm)	180.00	135.00	120.00	75.00	45.00	45.00	45.00	60.00	75.00	120.00	150.00	165.00		
Effective evapotranspiration coefficients	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67		
Effective evapotranspiration (mm)	120.60	90.45	80.40	50.25	30.15	30.15	30.15	40.20	50.25	80.40	100.50	110.55	**814.05**	**mm**
Soil moisture content (%)	0.00%	0.00%	0.00%	0.00%	0.00%	0.05%	0.17%	0.00%	0.00%	0.00%	0.00%	0.00%		
Percolation (to aquafers) ratio	1.00	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	1.00	1.00	1.00		
Average rainfall (ML/month)	33	34	258	128	617	1530	1794	1298	506	342	465	990	**7993**	**ML**
Effective evapotranspiration (ML/month)	5627	4220	3751	2345	1407	1407	1407	1876	2345	3751	4689	5158	**37984**	**ML**
Percolation to aquifers (ML/month)	0.0	0.0	0.0	0.0	0.0	122.5	384.6	0.0	0.0	0.0	0.0	0.0	**507**	**ML**
Balance (ML/month)	-5595	-4187	-3494	-2217	-790	0	2	-577	-1839	-3410	-4224	-4168		
Impounded volume (ML)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.2**	**2.6**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**		

Low Permeability

Por. (n) 10.00% K= 1.00E-06 m/s

Entire Mine Site Catchment

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	
Drainage area (Ha)	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00		
1957 monthly rainfall (mm)	0.70	0.72	5.52	2.74	13.22	32.78	38.44	27.83	10.84	7.32	9.98	21.22	**171.31**	**mm**
Potential evapotranspiration (mm)	180.00	135.00	120.00	75.00	45.00	45.00	45.00	60.00	75.00	120.00	150.00	165.00		
Effective evapotranspiration coefficients	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67		
Effective evapotranspiration (mm)	120.60	90.45	80.40	50.25	30.15	30.15	30.15	40.20	50.25	80.40	100.50	110.55	**814.05**	**mm**
Soil moisture content (%)	0.00%	0.00%	0.00%	0.00%	0.00%	0.05%	0.17%	0.00%	0.00%	0.00%	0.00%	0.00%		
Percolation (to aquafers) ratio	1.00	1.00	1.00	1.00	1.00	0.99	0.98	1.00	1.00	1.00	1.00	1.00		
Average rainfall (ML/month)	18	19	142	71	341	845	991	717	279	189	257	547	**4415**	**ML**
Effective evapotranspiration (ML/month)	3108	2331	2072	1295	777	777	777	1036	1295	2072	2590	2849	**20978**	**ML**
Percolation to aquifers (ML/month)	0.0	0.0	0.0	0.0	0.0	67.3	208.8	0.0	0.0	0.0	0.0	0.0	**276**	**ML**
Balance (ML/month)	-3090	-2312	-1930	-1224	-436	0	5	-319	-1016	-1883	-2333	-2302		
Impounded volume (ML)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.5**	**5.4**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**		

Very Low Permeability

Por. (n) 3.50% K= 1.00E-08 m/s

Entire Mine Site Catchment

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	
Drainage area (Ha)	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00		
1957 monthly rainfall (mm)	0.70	0.72	5.52	2.74	13.22	32.78	38.44	27.83	10.84	7.32	9.98	21.22	**171.31**	**mm**
Potential evapotranspiration (mm)	180.00	135.00	120.00	75.00	45.00	45.00	45.00	60.00	75.00	120.00	150.00	165.00		
Effective evapotranspiration coefficients	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67		
Effective evapotranspiration (mm)	120.60	90.45	80.40	50.25	30.15	30.15	30.15	40.20	50.25	80.40	100.50	110.55	**814.05**	**mm**
Soil moisture content (%)	0.00%	0.00%	0.00%	0.00%	0.00%	0.05%	0.17%	0.00%	0.00%	0.00%	0.00%	0.00%		
Percolation (to aquafers) ratio	1.00	1.00	1.00	1.00	1.00	0.98	0.93	1.00	1.00	1.00	1.00	1.00		
Average rainfall (ML/month)	4	4	33	16	79	197	231	167	65	44	60	128	**1030**	**ML**
Effective evapotranspiration (ML/month)	725	544	483	302	181	181	181	242	302	483	604	664	**4892**	**ML**
Percolation to aquifers (ML/month)	0.0	0.0	0.0	0.0	0.0	15.5	46.6	0.0	0.0	0.0	0.0	0.0	**62**	**ML**
Balance (ML/month)	-721	-539	-450	-286	-102	0	3	-74	-237	-439	-544	-537		
Impounded volume (ML)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.3**	**3.6**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**		

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
TOTAL Impounded Volume	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.1**	**11.7**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

PRE MINING 1968

Medium Permeability	Por. (n)	15.00%		K=	1.20E-04	m/s		309.34						
Entire Mine Site Catchment														
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**	
Drainage area (Ha)	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00		
1968 monthly rainfall (mm)	29.53	42.10	59.60	35.89	59.70	110.35	81.90	57.39	27.24	29.62	23.17	24.83	**581.32**	**mm**
Potential evapotranspiration (mm)	180.00	135.00	120.00	75.00	45.00	45.00	45.00	60.00	75.00	120.00	150.00	165.00		
Effective evapotranspiration coefficients	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67		
Effective evapotranspiration (mm)	120.60	90.45	80.40	50.25	30.15	30.15	30.15	40.20	50.25	80.40	100.50	110.55	**814.05**	**mm**
Soil moisture content (%)	0.00%	0.00%	0.00%	0.00%	0.59%	1.60%	1.04%	0.34%	0.00%	0.00%	0.00%	0.00%		
Percolation (to aquafers) ratio	1.00	1.00	1.00	1.00	0.98	0.94	0.96	0.99	1.00	1.00	1.00	1.00		
Average rainfall (ML/month)	1378	1964	2781	1675	2785	5149	3821	2678	1271	1382	1081	1158	**27124**	**ML**
Effective evapotranspiration (ML/month)	5627	4220	3751	2345	1407	1407	1407	1876	2345	3751	4689	5158	**37984**	**ML**
Percolation to aquifers (ML/month)	0.0	0.0	0.0	0.0	1348.4	3523.0	2322.7	791.9	0.0	0.0	0.0	0.0	**7986**	**ML**
Balance (ML/month)	-4249	-2256	-970	-670	30	219	92	10	-1074	-2369	-3608	-4000		
Impounded volume (ML)	**0.0**	**0.0**	**0.0**	**0.0**	**30.2**	**249.4**	**341.4**	**351.6**	**0.0**	**0.0**	**0.0**	**0.0**		

Low Permeability	Por. (n)	10.00%		K=	1.00E-06	m/s								
Entire Mine Site Catchment														
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**	
Drainage area (Ha)	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00		
1968 monthly rainfall (mm)	29.53	42.10	59.60	35.89	59.70	110.35	81.90	57.39	27.24	29.62	23.17	24.83	**581.32**	**mm**
Potential evapotranspiration (mm)	180.00	135.00	120.00	75.00	45.00	45.00	45.00	60.00	75.00	120.00	150.00	165.00		
Effective evapotranspiration coefficients	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67		
Effective evapotranspiration (mm)	120.60	90.45	80.40	50.25	30.15	30.15	30.15	40.20	50.25	80.40	100.50	110.55	**814.05**	**mm**
Soil moisture content (%)	0.00%	0.00%	0.00%	0.00%	0.59%	1.60%	1.04%	0.34%	0.00%	0.00%	0.00%	0.00%		
Percolation (to aquafers) ratio	1.00	1.00	1.00	1.00	0.92	0.78	0.86	0.95	1.00	1.00	1.00	1.00		
Average rainfall (ML/month)	761	1085	1536	925	1538	2844	2111	1479	702	763	597	640	**14981**	**ML**
Effective evapotranspiration (ML/month)	3108	2331	2072	1295	777	777	777	1036	1295	2072	2590	2849	**20978**	**ML**
Percolation to aquifers (ML/month)	0.0	0.0	0.0	0.0	699.5	1620.3	1145.4	422.0	0.0	0.0	0.0	0.0	**3887**	**ML**
Balance (ML/month)	-2347	-1246	-536	-370	62	446	188	21	-593	-1309	-1993	-2209		
Impounded volume (ML)	**0.0**	**0.0**	**0.0**	**0.0**	**61.9**	**508.4**	**696.6**	**717.7**	**124.6**	**0.0**	**0.0**	**0.0**		

Very Low Permeability	Por. (n)	3.50%		K=	1.00E-08	m/s								
Entire Mine Site Catchment														
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**	
Drainage area (Ha)	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00		
1968 monthly rainfall (mm)	29.53	42.10	59.60	35.89	59.70	110.35	81.90	57.39	27.24	29.62	23.17	24.83	**581.32**	**mm**
Potential evapotranspiration (mm)	180.00	135.00	120.00	75.00	45.00	45.00	45.00	60.00	75.00	120.00	150.00	165.00		
Effective evapotranspiration coefficients	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67		
Effective evapotranspiration (mm)	120.60	90.45	80.40	50.25	30.15	30.15	30.15	40.20	50.25	80.40	100.50	110.55	**814.05**	**mm**
Soil moisture content (%)	0.00%	0.00%	0.00%	0.00%	0.59%	1.60%	1.04%	0.34%	0.00%	0.00%	0.00%	0.00%		
Percolation (to aquafers) ratio	1.00	1.00	1.00	1.00	0.77	0.42	0.61	0.87	1.00	1.00	1.00	1.00		
Average rainfall (ML/month)	177	253	358	216	359	663	492	345	164	178	139	149	**3494**	**ML**
Effective evapotranspiration (ML/month)	725	544	483	302	181	181	181	242	302	483	604	664	**4892**	**ML**
Percolation to aquifers (ML/month)	0.0	0.0	0.0	0.0	137.1	204.3	190.4	89.4	0.0	0.0	0.0	0.0	**621**	**ML**
Balance (ML/month)	-547	-291	-125	-86	41	278	121	14	-138	-305	-465	-515		
Impounded volume (ML)	**0.0**	**0.0**	**0.0**	**0.0**	**40.5**	**318.2**	**438.8**	**452.7**	**314.4**	**9.2**	**0.0**	**0.0**		
TOTAL Impounded Volume	**0.0**	**0.0**	**0.0**	**0.0**	**132.6**	**1076.0**	**1476.8**	**1522.0**	**439.0**	**9.2**	**0.0**	**0.0**		

PRE-MINING: 1979

Medium Permeability	Por. (η)	15.00%		K=	1.20E-04	m/s								
Entire Mine Site Catchment														
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**	
Drainage area (Ha)	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00		
1979 monthly rainfall (mm)	6.02	9.51	2.79	16.16	71.49	10.77	51.75	55.31	116.12	21.63	58.44	12.42	**432.42**	**mm**
Potential evapotranspiration (mm)	180.00	135.00	120.00	75.00	45.00	45.00	45.00	60.00	75.00	120.00	150.00	165.00		
Effective evapotranspiration coefficients	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67		
Effective evapotranspiration (mm)	120.60	90.45	80.40	50.25	30.15	30.15	30.15	40.20	50.25	80.40	100.50	110.55	**814.05**	**mm**
Soil moisture content (%)	0.00%	0.00%	0.00%	0.00%	0.83%	0.00%	0.43%	0.30%	1.32%	0.00%	0.00%	0.00%		
Percolation (to aquafers) ratio	1.00	1.00	1.00	1.00	0.97	1.00	0.98	0.99	0.95	1.00	1.00	1.00		
Average rainfall (ML/month)	281	444	130	754	3336	503	2415	2581	5418	1009	2727	579	**20177**	**ML**
Effective evapotranspiration (ML/month)	5627	4220	3751	2345	1407	1407	1407	1876	2345	3751	4689	5158	**37984**	**ML**
Percolation to aquifers (ML/month)	0.0	0.0	0.0	0.0	1870.0	0.0	991.8	697.0	2925.1	0.0	0.0	0.0	**6484**	**ML**
Balance (ML/month)	-5346	-3776	-3621	-1591	59	-904	16	8	148	-2742	-1962	-4579		
Impounded volume (ML)	**0.0**	**0.0**	**0.0**	**0.0**	**58.9**	**0.0**	**16.2**	**24.1**	**172.6**	**0.0**	**0.0**	**0.0**		

Low Permeability	Por. (η)	10.00%		K=	1.00E-06	m/s								
Entire Mine Site Catchment														
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**	
Drainage area (Ha)	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00		
1979 monthly rainfall (mm)	6.02	9.51	2.79	16.16	71.49	10.77	51.75	55.31	116.12	21.63	58.44	12.42	**432.42**	**mm**
Potential evapotranspiration (mm)	180.00	135.00	120.00	75.00	45.00	45.00	45.00	60.00	75.00	120.00	150.00	165.00		
Effective evapotranspiration coefficients	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67		
Effective evapotranspiration (mm)	120.60	90.45	80.40	50.25	30.15	30.15	30.15	40.20	50.25	80.40	100.50	110.55	**814.05**	**mm**
Soil moisture content (%)	0.00%	0.00%	0.00%	0.00%	0.83%	0.00%	0.43%	0.30%	1.32%	0.00%	0.00%	0.00%		
Percolation (to aquafers) ratio	1.00	1.00	1.00	1.00	0.89	1.00	0.94	0.96	0.82	1.00	1.00	1.00		
Average rainfall (ML/month)	155	245	72	416	1842	278	1334	1425	2992	557	1506	320	**11143**	**ML**
Effective evapotranspiration (ML/month)	3108	2331	2072	1295	777	777	777	1036	1295	2072	2590	2849	**20978**	**ML**
Percolation to aquifers (ML/month)	0.0	0.0	0.0	0.0	944.7	0.0	523.5	373.0	1394.4	0.0	0.0	0.0	**3236**	**ML**
Balance (ML/month)	-2953	-2086	-2000	-878	121	-499	33	16	303	-1515	-1084	-2529		
Impounded volume (ML)	**0.0**	**0.0**	**0.0**	**0.0**	**120.6**	**0.0**	**33.2**	**49.5**	**352.6**	**0.0**	**0.0**	**0.0**		

Very Low Permeability	Por. (η)	3.50%		K=	1.00E-08	m/s								
Entire Mine Site Catchment														
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**	
Drainage area (Ha)	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00		
1979 monthly rainfall (mm)	6.02	9.51	2.79	16.16	71.49	10.77	51.75	55.31	116.12	21.63	58.44	12.42	**432.42**	**mm**
Potential evapotranspiration (mm)	180.00	135.00	120.00	75.00	45.00	45.00	45.00	60.00	75.00	120.00	150.00	165.00		
Effective evapotranspiration coefficients	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67		
Effective evapotranspiration (mm)	120.60	90.45	80.40	50.25	30.15	30.15	30.15	40.20	50.25	80.40	100.50	110.55	**814.05**	**mm**
Soil moisture content (%)	0.00%	0.00%	0.00%	0.00%	0.83%	0.00%	0.43%	0.30%	1.32%	0.00%	0.00%	0.00%		
Percolation (to aquafers) ratio	1.00	1.00	1.00	1.00	0.69	1.00	0.83	0.88	0.52	1.00	1.00	1.00		
Average rainfall (ML/month)	36	57	17	97	430	65	311	332	698	130	351	75	**2599**	**ML**
Effective evapotranspiration (ML/month)	725	544	483	302	181	181	181	242	302	483	604	664	**4892**	**ML**
Percolation to aquifers (ML/month)	0.0	0.0	0.0	0.0	170.4	0.0	108.0	80.0	204.4	0.0	0.0	0.0	**563**	**ML**
Balance (ML/month)	-689	-486	-466	-205	78	-116	22	11	192	-353	-253	-590		
Impounded volume (ML)	**0.0**	**0.0**	**0.0**	**0.0**	**78.1**	**0.0**	**21.9**	**32.6**	**224.2**	**0.0**	**0.0**	**0.0**		

TOTAL Impounded Volume	**0.0**	**0.0**	**0.0**	**0.0**	**257.6**	**0.0**	**71.2**	**106.2**	**749.3**	**0.0**	**0.0**	**0.0**

PRE-MINING: 1992

Medium Permeability

Por. (η) 15.00% K= 1.20E-04 m/s

Entire Mine Site Catchment

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	
Drainage area (Ha)	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00		
1992 monthly rainfall (mm)	1.04	6.88	39.48	53.43	54.74	28.61	22.75	73.48	83.30	71.72	57.97	87.11	**580.50**	**mm**
Potential evapotranspiration (mm)	180.00	135.00	120.00	75.00	45.00	45.00	45.00	60.00	75.00	120.00	150.00	165.00		
Effective evapotranspiration coefficients	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67		
Effective evapotranspiration (mm)	120.60	90.45	80.40	50.25	30.15	30.15	30.15	40.20	50.25	80.40	100.50	110.55	**814.05**	**mm**
Soil moisture content (%)	0.00%	0.00%	0.00%	0.06%	0.49%	0.00%	0.00%	0.67%	0.66%	0.00%	0.00%	0.00%		
Percolation (to aquafers) ratio	1.00	1.00	1.00	1.00	0.98	1.00	1.00	0.98	0.98	1.00	1.00	1.00		
Average rainfall (ML/month)	48	321	1842	2493	2554	1335	1061	3429	3887	3346	2705	4065	**27086**	**ML**
Effective evapotranspiration (ML/month)	5627	4220	3751	2345	1407	1407	1407	1876	2345	3751	4689	5158	**37984**	**ML**
Percolation to aquifers (ML/month)	0.0	0.0	0.0	148.0	1126.3	0.0	0.0	1514.6	1504.5	0.0	0.0	0.0	**4293**	**ML**
Balance (ML/month)	-5579	-3899	-1909	0	21	-72	-345	38	38	-405	-1985	-1094		
Impounded volume (ML)	**0.0**	**0.0**	**0.0**	**0.4**	**21.3**	**0.0**	**0.0**	**38.2**	**76.0**	**0.0**	**0.0**	**0.0**		

Low Permeability

Por. (η) 10.00% K= 1.00E-06 m/s

Entire Mine Site Catchment

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	
Drainage area (Ha)	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00		
1992 monthly rainfall (mm)	1.04	6.88	39.48	53.43	54.74	28.61	22.75	73.48	83.30	71.72	57.97	87.11	**580.50**	**mm**
Potential evapotranspiration (mm)	180.00	135.00	120.00	75.00	45.00	45.00	45.00	60.00	75.00	120.00	150.00	165.00		
Effective evapotranspiration coefficients	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67		
Effective evapotranspiration (mm)	120.60	90.45	80.40	50.25	30.15	30.15	30.15	40.20	50.25	80.40	100.50	110.55	**814.05**	**mm**
Soil moisture content (%)	0.00%	0.00%	0.00%	0.06%	0.49%	0.00%	0.00%	0.67%	0.66%	0.00%	0.00%	0.00%		
Percolation (to aquafers) ratio	1.00	1.00	1.00	0.99	0.93	1.00	1.00	0.91	0.91	1.00	1.00	1.00		
Average rainfall (ML/month)	27	177	1018	1377	1411	737	586	1894	2147	1848	1494	2245	**14960**	**ML**
Effective evapotranspiration (ML/month)	3108	2331	2072	1295	777	777	777	1036	1295	2072	2590	2849	**20978**	**ML**
Percolation to aquifers (ML/month)	0.0	0.0	0.0	81.2	590.6	0.0	0.0	779.2	774.4	0.0	0.0	0.0	**2225**	**ML**
Balance (ML/month)	-3081	-2154	-1054	1	43	-40	-191	78	77	-224	-1096	-604		
Impounded volume (ML)	**0.0**	**0.0**	**0.0**	**0.7**	**43.7**	**4.0**	**0.0**	**78.4**	**155.8**	**0.0**	**0.0**	**0.0**		

Very Low Permeability

Por. (η) 3.50% K= 1.00E-08 m/s

Entire Mine Site Catchment

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	
Drainage area (Ha)	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00		
1992 monthly rainfall (mm)	1.04	6.88	39.48	53.43	54.74	28.61	22.75	73.48	83.30	71.72	57.97	87.11	**580.50**	**mm**
Potential evapotranspiration (mm)	180.00	135.00	120.00	75.00	45.00	45.00	45.00	60.00	75.00	120.00	150.00	165.00		
Effective evapotranspiration coefficients	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67		
Effective evapotranspiration (mm)	120.60	90.45	80.40	50.25	30.15	30.15	30.15	40.20	50.25	80.40	100.50	110.55	**814.05**	**mm**
Soil moisture content (%)	0.00%	0.00%	0.00%	0.06%	0.49%	0.00%	0.00%	0.67%	0.66%	0.00%	0.00%	0.00%		
Percolation (to aquafers) ratio	1.00	1.00	1.00	0.97	0.81	1.00	1.00	0.74	0.75	1.00	1.00	1.00		
Average rainfall (ML/month)	6	41	237	321	329	172	137	442	501	431	348	524	**3489**	**ML**
Effective evapotranspiration (ML/month)	725	544	483	302	181	181	181	242	302	483	604	664	**4892**	**ML**
Percolation to aquifers (ML/month)	0.0	0.0	0.0	18.6	119.5	0.0	0.0	148.9	148.2	0.0	0.0	0.0	**435**	**ML**
Balance (ML/month)	-719	-502	-246	0	28	-9	-44	51	50	-52	-256	-141		
Impounded volume (ML)	**0.0**	**0.0**	**0.0**	**0.5**	**28.7**	**19.4**	**0.0**	**51.1**	**101.6**	**49.4**	**0.0**	**0.0**		

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
TOTAL Impounded Volume	**0.0**	**0.0**	**0.0**	**1.6**	**93.7**	**23.5**	**0.0**	**167.8**	**333.4**	**49.4**	**0.0**	**0.0**

PRE-MINING: 2011

Medium Permeability

Por. (η) 15.00% K= 1.20E-04 m/s

Entire Mine Site Catchment

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	
Drainage area (Ha)	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00		
2011 monthly rainfall (mm)	0.89	88.77	54.43	12.50	30.54	29.58	44.25	52.78	32.28	44.07	7.25	15.00	**412.33**	**mm**
Potential evapotranspiration (mm)	180.00	135.00	120.00	75.00	45.00	45.00	45.00	60.00	75.00	120.00	150.00	165.00		
Effective evapotranspiration coefficients	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67		
Effective evapotranspiration (mm)	120.60	90.45	80.40	50.25	30.15	30.15	30.15	40.20	50.25	80.40	100.50	110.55	**814.05**	**mm**
Soil moisture content (%)	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.28%	0.25%	0.00%	0.00%	0.00%	0.00%		
Percolation (to aquafers) ratio	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	1.00	1.00	1.00	1.00		
Average rainfall (ML/month)	41	4142	2540	583	1425	1380	2065	2463	1506	2056	338	700	**19240**	**ML**
Effective evapotranspiration (ML/month)	5627	4220	3751	2345	1407	1407	1407	1876	2345	3751	4689	5158	**37984**	**ML**
Percolation to aquifers (ML/month)	0.0	0.0	0.0	0.0	18.3	0.0	651.2	581.7	0.0	0.0	0.0	0.0	**1251**	**ML**
Balance (ML/month)	-5586	-78	-1212	-1761	0	-27	7	5	-839	-1695	-4351	-4458		
Impounded volume (ML)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**6.9**	**12.4**	**0.0**	**0.0**	**0.0**	**0.0**		

Low Permeability

Por. (η) 10.00% K= 1.00E-06 m/s

Entire Mine Site Catchment

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	
Drainage area (Ha)	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00		
2011 monthly rainfall (mm)	0.89	88.77	54.43	12.50	30.54	29.58	44.25	52.78	32.28	44.07	7.25	15.00	**412.33**	**mm**
Potential evapotranspiration (mm)	180.00	135.00	120.00	75.00	45.00	45.00	45.00	60.00	75.00	120.00	150.00	165.00		
Effective evapotranspiration coefficients	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67		
Effective evapotranspiration (mm)	120.60	90.45	80.40	50.25	30.15	30.15	30.15	40.20	50.25	80.40	100.50	110.55	**814.05**	**mm**
Soil moisture content (%)	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.28%	0.25%	0.00%	0.00%	0.00%	0.00%		
Percolation (to aquafers) ratio	1.00	1.00	1.00	1.00	1.00	1.00	0.96	0.97	1.00	1.00	1.00	1.00		
Average rainfall (ML/month)	23	2288	1403	322	787	762	1140	1360	832	1136	187	387	**10626**	**ML**
Effective evapotranspiration (ML/month)	3108	2331	2072	1295	777	777	777	1036	1295	2072	2590	2849	**20978**	**ML**
Percolation to aquifers (ML/month)	0.0	0.0	0.0	0.0	10.1	0.0	349.3	313.0	0.0	0.0	0.0	0.0	**672**	**ML**
Balance (ML/month)	-3085	-43	-669	-973	0	-15	14	11	-463	-936	-2403	-2462		
Impounded volume (ML)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**14.2**	**25.5**	**0.0**	**0.0**	**0.0**	**0.0**		

Very Low Permeability

Por. (η) 3.50% K= 1.00E-08 m/s

Entire Mine Site Catchment

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	
Drainage area (Ha)	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00		
2011 monthly rainfall (mm)	0.89	88.77	54.43	12.50	30.54	29.58	44.25	52.78	32.28	44.07	7.25	15.00	**412.33**	**mm**
Potential evapotranspiration (mm)	180.00	135.00	120.00	75.00	45.00	45.00	45.00	60.00	75.00	120.00	150.00	165.00		
Effective evapotranspiration coefficients	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67		
Effective evapotranspiration (mm)	120.60	90.45	80.40	50.25	30.15	30.15	30.15	40.20	50.25	80.40	100.50	110.55	**814.05**	**mm**
Soil moisture content (%)	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.28%	0.25%	0.00%	0.00%	0.00%	0.00%		
Percolation (to aquafers) ratio	1.00	1.00	1.00	1.00	1.00	1.00	0.89	0.90	1.00	1.00	1.00	1.00		
Average rainfall (ML/month)	5	533	327	75	184	178	266	317	194	265	44	90	**2478**	**ML**
Effective evapotranspiration (ML/month)	725	544	483	302	181	181	181	242	302	483	604	664	**4892**	**ML**
Percolation to aquifers (ML/month)	0.0	0.0	0.0	0.0	2.3	0.0	75.4	68.1	0.0	0.0	0.0	0.0	**146**	**ML**
Balance (ML/month)	-719	-10	-156	-227	0	-3	9	8	-108	-218	-560	-574		
Impounded volume (ML)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**9.4**	**16.9**	**0.0**	**0.0**	**0.0**	**0.0**		

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
TOTAL Impounded Volume	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**30.5**	**54.8**	**0.0**	**0.0**	**0.0**	**0.0**

PRE-MINING: 2013 – MODEL CALIBRATION

Medium Permeability

Por. (n) 15.00% K= 1.20E-04 m/s

Entire Mine Site Catchment

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	
Drainage area (Ha)	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00	4666.00		
2013 monthly rainfall (mm)	3.23	25.85	32.57	23.59	30.35	56.96	64.50						**237.05**	**mm**
Potential evapotranspiration (mm)	180.00	135.00	120.00	75.00	45.00	45.00	45.00	60.00	75.00	120.00	150.00	165.00		
Effective evapotranspiration coefficients	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67		
Effective evapotranspiration (mm)	120.60	90.45	80.40	50.25	30.15	30.15	30.15	40.20	50.25	80.40	100.50	110.55	**814.05**	**mm**
Soil moisture content (%)	0.00%	0.00%	0.00%	0.00%	0.00%	0.54%	0.69%	0.00%	0.00%	0.00%	0.00%	0.00%		
Percolation (to aquafers) ratio	1.00	1.00	1.00	1.00	1.00	0.98	0.97	1.00	1.00	1.00	1.00	1.00		
Average rainfall (ML/month)	151	1206	1520	1101	1416	2658	3010	0	0	0	0	0	**11061**	**ML**
Effective evapotranspiration (ML/month)	5627	4220	3751	2345	1407	1407	1407	1876	2345	3751	4689	5158	**37984**	**ML**
Percolation to aquifers (ML/month)	0.0	0.0	0.0	0.0	9.5	1225.9	1562.0	0.0	0.0	0.0	0.0	0.0	**2797**	**ML**
Balance (ML/month)	-5476	-3014	-2232	-1244	0	25	41	-1876	-2345	-3751	-4689	-5158		
Impounded volume (ML)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**24.9**	**65.6**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**		

Low Permeability

Por. (n) 10.00% K= 1.00E-06 m/s

Entire Mine Site Catchment

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	
Drainage area (Ha)	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00	2577.00		
2013 monthly rainfall (mm)	3.23	25.85	32.57	23.59	30.35	56.96	64.50						**237.05**	**mm**
Potential evapotranspiration (mm)	180.00	135.00	120.00	75.00	45.00	45.00	45.00	60.00	75.00	120.00	150.00	165.00		
Effective evapotranspiration coefficients	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67		
Effective evapotranspiration (mm)	120.60	90.45	80.40	50.25	30.15	30.15	30.15	40.20	50.25	80.40	100.50	110.55	**814.05**	**mm**
Soil moisture content (%)	0.00%	0.00%	0.00%	0.00%	0.00%	0.54%	0.69%	0.00%	0.00%	0.00%	0.00%	0.00%		
Percolation (to aquafers) ratio	1.00	1.00	1.00	1.00	1.00	0.93	0.91	1.00	1.00	1.00	1.00	1.00		
Average rainfall (ML/month)	83	666	839	608	782	1468	1662	0	0	0	0	0	**6109**	**ML**
Effective evapotranspiration (ML/month)	3108	2331	2072	1295	777	777	777	1036	1295	2072	2590	2849	**20978**	**ML**
Percolation to aquifers (ML/month)	0.0	0.0	0.0	0.0	5.3	639.8	801.7	0.0	0.0	0.0	0.0	0.0	**1447**	**ML**
Balance (ML/month)	-3025	-1665	-1233	-687	0	51	84	-1036	-1295	-2072	-2590	-2849		
Impounded volume (ML)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**51.0**	**134.6**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**		

Very Low Permeability

Por. (n) 3.50% K= 1.00E-08 m/s

Entire Mine Site Catchment

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	
Drainage area (Ha)	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00	601.00		
2013 monthly rainfall (mm)	3.23	25.85	32.57	23.59	30.35	56.96	64.50						**237.05**	**mm**
Potential evapotranspiration (mm)	180.00	135.00	120.00	75.00	45.00	45.00	45.00	60.00	75.00	120.00	150.00	165.00		
Effective evapotranspiration coefficients	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67		
Effective evapotranspiration (mm)	120.60	90.45	80.40	50.25	30.15	30.15	30.15	40.20	50.25	80.40	100.50	110.55	**814.05**	**mm**
Soil moisture content (%)	0.00%	0.00%	0.00%	0.00%	0.00%	0.54%	0.69%	0.00%	0.00%	0.00%	0.00%	0.00%		
Percolation (to aquafers) ratio	1.00	1.00	1.00	1.00	1.00	0.79	0.74	1.00	1.00	1.00	1.00	1.00		
Average rainfall (ML/month)	19	155	196	142	182	342	388	0	0	0	0	0	**1425**	**ML**
Effective evapotranspiration (ML/month)	725	544	483	302	181	181	181	242	302	483	604	664	**4892**	**ML**
Percolation to aquifers (ML/month)	0.0	0.0	0.0	0.0	1.2	127.7	152.0	0.0	0.0	0.0	0.0	0.0	**281**	**ML**
Balance (ML/month)	-705	-388	-287	-160	0	33	54	-242	-302	-483	-604	-664		
Impounded volume (ML)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**33.5**	**87.9**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**		

	Jan	Feb	Mar	Apr	May	Jun	Jul
TOTAL Impounded Volume	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**109.3**	**288.0**

Appendix F Swale Dewatering Pipes Hydraulic Calculations

APPENDIX F: SWALE DEWATERING PIPE HYDRAULIC CALCULATIONS

		Surface Water ex-Pit Dewatering System - Swales				
	Contributing Catchment	S9	S10	S16	S19	S20
	10 Day Design Flow (m^3/s)	0.017	0.009	0.029	0.0004	0.017
	Mine Process Pond EL	80	80	80	80	80
	Stage Min EL	60	60	60	60	60
	Static head	20	20	20	20	20
	No Pumps per Stage	1	1	1	1	1
	Unit Flow (m3/s)	0.017	0.009	0.029	0.000	0.017
Unit Pipeline	Unit Pipe Length (m)	100.0	20.0	20.0	1050.0	200.0
	Unit Pipe Diametre (m)	0.10	0.08	0.14	0.02	0.10
	Unit Pipe DN (m) - PN20	DN 160	DN 110	DN 160	DN 110	DN 160
	Unit Pipe ID (m)	0.141	0.096	0.141	0.096	0.141
	RH	0.0705	0.048	0.0705	0.048	0.0705
	n (HDPE)	0.01	0.01	0.01	0.01	0.01
	V (m/s)	1.07	1.26	1.85	0.05	1.07
	I (m/m)	0.0040	0.0091	0.0117	0.0000	0.0040
	Headloss (m)	0.59	0.27	0.35	0.02	1.19
Collecting 3 Pipeline	Unit Pipe Length (m)	6500.0	6200.0	5200.0	4400.0	4500.0
	Flow (m3/s)	0.072	0.072	0.072	0.072	0.072
	Unit Pipe Diametre (m)	0.21	0.21	0.21	0.21	0.21
	Unit Pipe DN (m) - PN20	DN 450	DN 450	DN 450	DN 450	DN 450
	Unit Pipe ID (m)	0.396	0.396	0.396	0.396	0.396
	RH	0.198	0.198	0.198	0.198	0.198
	n (HDPE)	0.01	0.01	0.01	0.01	0.01
	V (m/s)	0.58	0.58	0.58	0.58	0.58
	I (m/m)	0.0003	0.0003	0.0003	0.0003	0.0003
	Headloss (m)	2.88	2.75	2.30	1.95	1.99
	Pumping head (m)	23.47	23.02	22.65	21.97	23.18
	No Stages	1	1	1	1	1
	No Pumps Total	1	1	1	1	1
	Unit Head (m)	23.47	23.02	22.65	21.97	23.18
	Unit Pumping Cap (kW)	5.2	2.8	8.5	0.1	5.1
	Pumping capacity (kW)	5.2	2.8	8.5	0.1	5.1
	Motor capacity (kW)	7.9	4.2	13.1	0.2	7.8